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Development Document for Proposed Effluent Limitations Guidelines New Source Performance Standards, and Pretreatment Standards for the Coal Mining Point Source Category

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FOR PROPOSED
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NEW SOURCE PERFORMANCE STANDARDS,
AND
PRETREATMENT STANDARDS
FOR THE
COAL MINING
POINT SOURCE CATEGORY

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SECTION I

SUMMARY

The primary purpose of this study was to determine the presence and concentrations of the 129 toxic or "priority" pollutants in the coal mining point source category for possible regulation. This development document presents the technical data base developed by EPA with regard to these pollutants and their treatability for regulation under the Clean Water Act. The concentrations of conventional and nonconventional pollutants were also examined for the establishment of effluent limitations guidelines based on the application of the best conventional pollutant control technology (BCT) and the best available technology economically achievable (BAT), respectively. Necessary modifications to prior regulations based on best practicable control technology currently available (BPT) were also identified. Treatment technologies were also assessed for designation as the best available demonstrated technology upon which new source performance standards (NSPS) are based. This document outlines the technology options considered and the rationale for selecting each technology level. These technology levels are the basis for the proposed effluent limitations.

A second purpose of this study was to assess the need for establishing effluent limitations to regulate discharges from surface and deep (underground) mines after cessation of active mining. The wastewaters from these facilities where coal extraction has ceased are referred to as "post-mining discharges."

A third purpose was to assess the appropriateness of establishing a separate subcategory for regulation of discharges from coal mines in the western United States.

A fourth purpose was to review and, if necessary, augment existing effluent limitations during rainfall and snowmelt conditions. More specifically, this included an analysis of candidate technologies and achievable pollutant removals to effectively control discharges during what is presently the catastrophic precipitation event (CPE) exemption period.

SUBCATEGORIZATION

On 26 April 1977, the Agency promulgated BPT effluent limitations for three subcategories in the coal mining point source category. These subcategories include acid drainage mines, alkaline drainage mines, and preparation plants and associated areas. On 12 January 1979, the Agency published new source performance standards for these three subcategories. Two additional subcategories (areas under reclamation and western mines) were also established at that time.

After an extensive statistical and engineering analysis of category profile factors, the existing BPT and NSPS subcategorization scheme was modified to include a number of revisions.

First, post mining discharges are proposed as a subcategory for regulation of effluents from surface and deep mines. For surface mines, areas where coal extraction and recontouring have been completed and revegetation has been commenced will be subject to settleable solids and pH limitations. For deep mines, any discharge to surface waters after completion of active mining operations is subject to identical limitations as those in effect during active mining. Discharges from underground mines where coal removal has been completed present a continuing source of wastewater pollution requiring control. Under the current proposal, when the applicable reclamation bond has been released (signifying the successful institution of appropriate sealing and other mine closure practices), the operator no longer needs to comply with EPA effluent limitations.

Second, the Agency has compiled and reviewed data from a number of programs investigating sedimentation pond performance during various rainfall events. Control of settleable solids and pH during the catastrophic precipitation event exemption period is proposed. These limitations will apply for increases in overflows resulting from rainfall events (or snowmelts of equivalent volumes) less than or equal to the 10-year, 24-hour storm. If a larger event occurs, operators will be required to comply with a pH limitation.

Third, the Agency has concluded that discharges from western mines do not warrant separate subcategorization.

The BAT subcategorization will be identical to the modified BPT categorization, since no additional factors were identified that substantially affect effluent characteristics. New source subcategorization is also identical to the modified BPT subcategorization scheme with the exception of the preparation plant and preparation plant associated area subcategory. This is subdivided into the two component categories, based upon differing treatabilities of wastewaters from the two areas.

The modified storm exemption will generally apply for all subcategories. However, no exemption will be available for discharges from underground workings at underground coal mines, or new source preparation plants. Rainfall will not substantially affect underground mine discharges, and storm relief is not necessary. Also, zero discharge regulation is being proposed for new source preparation plants, and thus no storm exemption is being proposed for this new source subcategory.

WATER SOURCES

The major sources of wastewater in the coal mining category include precipitation, surface runoff, ground water infiltration, and effluents from coal preparation plants. No process water is used in the mining phase, except for minor consumption in dust suppression, pump coolants, and firefighting needs. Therefore, pollution abatement in this industry must be approached differently, with reliance on operating and management practices for wastewater source control as well as end-of-pipe treatment technologies.

In the preparation phase, water is used to clean the raw coal. Water usage is typically 350 gallons per ton and is laden with coal and refuse fines which must be removed prior to discharge or reuse.

POLLUTANT COVERAGE

Toxic (Priority) Pollutants

Sampling and analysis for the 129 priority pollutants was conducted in this industry. Sixty-seven of the 114 toxic organics were not detected in treated mine wastewaters and 23 were detected in the effluent of only one or two mines and always below 10 ug/l. This level is considered to be the effective detectability limit for state-of-the-art analytical techniques. Ten of the toxic organic pollutants that were detected above 10 ug/l are believed to be present due to sampling, preservation, or analytical contamination. The remaining 14 were present in amounts too small to be effectively reduced by additional treatment technology. Thus, no regulations are proposed for the toxic organic compounds.

Five of the thirteen priority metals (antimony, beryllium, cadmium, silver, and thallium) were found in treated wastewaters at levels near or at their limits of detection by state-of-the-art analytical techniques. Therefore, no limitations are proposed for these pollutants. The remaining eight toxic metal pollutants (arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc) were found at levels above their detection limits but not uniformly throughout the industry. As discussed in Section VI, these metals are already effectively controlled by BPT technology, i.e., by treatment measures already in place.

Cyanide was found only in isolated cases and always at levels well below 10 ug/l. This concentration is well below treatability levels for quantifiable reduction of cyanide, and thus no limitation is proposed for this pollutant.

Chrysotile asbestos is the form of asbestos the Agency believes is the most important type to consider for regulation. This form was found in coal mining wastewaters at concentrations considered to be slightly above background levels, and thus no limitation is proposed. The Agency is expanding the asbestos data base and refining the analytical protocol for asbestos analyses. Further, toxicological studies are being conducted to determine the environmental effects of other forms of asbestos. Pending results from these programs, the Agency will assess the need for establishment of an effluent limitation for other asbestos forms.

Conventional Pollutants

The methodology for development of BCT effluent limitations was published on 29 August 1979 (44 FR 50732). The technologies considered for conventional pollutant removal in this industry are the same as those considered for toxic and nonconventional pollutant removal. Additionally, the Agency has determined that BAT technology is equivalent to BPT technology in this industry. Therefore, the BCT technology is also equivalent to BPT, and no incremental cost are incurred for BCT, i.e. BPT technology "passes," by definition, the BCT cost reasonableness test. Thus, the proposed BCT effluent limitations are identical to the BPT effluent limitations for the conventional pollutants pertinent to this industry (TSS and pH).

Nonconventional Pollutants

Iron and manganese are the only two nonconventional pollutants requiring control. These are effectively reduced by application of BPT. Therefore, the Agency is proposing that the BAT and NSPS limitations for iron and manganese be equivalent to the BPT levels.

TREATMENT AND CONTROL TECHNOLOGY

Amendments to BPT

No effluent limitations guidelines previously promulgated for the three BPT subcategories will be modified under this rulemaking except as outlined below.

Post Mining Discharges

Surface Mines. The Agency instituted a self-monitoring program involving 12 mine companines (21 sites) to establish performance data for sedimentation ponds receiving drainage primarily from areas under reclamation. Results indicate that settleable solids and pH are consistently reduced by properly designed, constructed, and maintained ponds or basins. Thus, the Agency is proposing limitations for these parameters for this subdivision. These effluent standards will apply from the time any acreage is first revegetated after active mining through release of the applicable reclamation bond for that acreage.

Underground Mines. Technology installed for treatment of raw drainage during active mining is the basis for regulation of underground mine drainage after active mining ceases. For acid underground mines, this will include neutralization and settling; settling alone is the appropriate technology for alkaline underground mines. Costs for operation of this equipment will be similar to annual costs during the active mine life.

Catastrophic Precipitation Event Exemption

Two separate studies (one at 21 sites, the other at 8 sites) have been commissioned to evaluate the performance of properly designed, constructed, and maintained sedimentation ponds during various rainfall events. Settleable solids and pH best characterize pond performance, and limitations are proposed for these parameters. Compliance with the limitations will be required for any discharges due to precipitation except those caused by a 10-year, 24-hour or greater storm. For these events, only a pH limitation will apply. These are proposed modifications to the exemption published in 44 FR 76788 (28 December 1979). The additional costs incurred for this modification will be confined to a minor amount of additional, inexpensive monitoring and some potential supplemental lime addition requirements. These are judged to be relatively minor with no specific cost estimates required. No alternate limitations or exemptions are provided for discharges from the underground workings of underground mines.

Western Mines

EPA evaluated wastewater characteristics and treatment technologies used by eastern and western mines to determine if differences exist in pertinent effluent characteristics between eastern and western mines. EPA determined that, while treatment systems at western mines discharge less frequently than those at eastern mines (due primarily to less precipitation and generally larger design volumes), effluent quality of western mine treatment systems is virtually the same as that for eastern mines. Thus, the proposal of a separate "western mines" subcategory is not appropriate for BAT and NSPS regulations for the coal mining industry. It should be noted, however, that at 40 CFR Part 122.62(L)(2) (45 FR 33450) and 40 CFR Part 123.7 (45 FR 33469), existing NPDES permit limitations which are more stringent than subsequently promulgated guidelines may be retained upon reissuance of the permit. Moreover, regional permit authorities have the freedom to impose more stringent requirements in light of site specific conditions (see 45 FR 33290, 19 May 1980).

BAT

Acid Drainage Mines

The Agency conducted sampling at 18 acid drainage mine sites and evaluated discharge monitoring reports (DMRs) submitted under the National Pollutant Discharge Elimination System (NPDES) for 56 additional facilities in this subcategory. Results indicate that treatment technology already installed, including neutralization, aeration, and settling, effects substantial reductions of the key pollutant parameters, including TSS, iron, manganese, and the toxic metals. Further, substantial reductions by additional treatment technologies, including flocculant addition and granular media filtration, were not achieved, according to treatability studies conducted by the Agency on wastewaters from a number of coal mines. Therefore, the BAT effluent limitations are based upon BPT technology and are identical to the BPT effluent limitations.

Alkaline Drainage Mines

The Agency sampled effluents from 28 different facilities and evaluated DMRs from an additional 32 coal mines in this subcategory. These effluents contain very low concentrations of toxic and nonconventional pollutants after application of settling, which is the treatment option upon which BPT limitations were promulgated. The Agency has thus concluded that BAT limitations will be equal to BPT effluent limitations.

Preparation Plants and Associated Areas

The Agency conducted a sampling program at 28 preparation plants during the BAT review. Further, an industry survey of wastewater treatment practices was instituted. One hundred and fifty-two plants responded to this survey. Discharge data were also collected from DMRs for an additional 12 sites. Although raw wastewater from this subcategory can contain very substantial amounts of TSS and metal species, these are significantly reduced by BPT-level technology, i.e., settling technology, with neutralization also necessary for acidic associated area drainage. Treated waters are often at least partially reused. A number of end-of-pipe treatment technologies and a zero discharge requirement were investigated for application in this subcategory. Where preparation plant wastewater can be segregated from associated area wastewater, zero discharge (or total recycle) of water can be achieved. Because it is currently common practice in the industry to combine these wastewaters for treatment, most operators would have to retrofit separate treatment systems for the two wastewaters. This involves substantial capital and annual expenditures. In contrast, these retrofit costs are not incurred for new facilities. Consequently, the Agency has proposed a zero discharge requirement for new sources while not applying such a requirement for existing sources. Discharges from existing sources were then evaluated to determine the merits of additional treatment downstream of the existing BPT treatment system. The two technologies investigated were flocculant addition and granular media filtration. Results indicate that neither of these achieved significant pollutant reduction beyond BPT. Therefore, BAT limitations will be identical to BPT limitations for this subcategory.

NEW SOURCE PERFORMANCE STANDARDS

New source performance standards will be identical to BAT effluent limitations for all subcategories except for the preparation plant subcategory. The proposed standard for preparation plants is no discharge of wastewater pollutants. This is the best available demonstrated technology, having been installed in a number of preparation plants in regions of varying topography and climate. Associated area drainage will be neutralized and settled independently of the preparation plant water circuit, for compliance with limitations equal to those established for BPT.

SECTION II

PROPOSED REGULATIONS

Three subcategories were established as the basis for promulgation of standards (see 42 FR 21380, 26 April 1977) based on the best practicable control technology currently available. At that time, the Agency withheld promulgation of standards for certain segments and other issues pending further data collection and analysis. The issues receiving further study include: (1) the appropriateness of a western mines subcategory, (2) the appropriateness of a post mining subcategory, (3) the type of storm relief granted to operators. The proposed BAT and new source limitations (42 FR 21380, 42 FR 46932, 44 FR 2586) were also reviewed by the Agency as required by the Clean Water Act of 1977 in keeping with the Act's emphasis on toxic pollutants. The law also required examination of the best conventional pollutant control technology (BCT) to treat conventional pollutants. Finally, the applicability of pretreatment standards and best management practices was investigated.

AMENDMENTS TO BPT REQUIREMENTS

Catastrophic Precipitation Event Exemption

EPA has instituted two sampling and analysis programs to characterize sedimentation pond performance parameters during various rainfall events. Results substantiate that settleable solids and pH, the two key parameters, can be effectively controlled during rainfall events (or snowmelt of equivalent volume) less than the 10-year, 24-hour design storm, as follows:

	Effluent Limitations*	
Effluent Characteristic	Maximum for any one day	Average of daily values for 30 consecutive days shall not exceed
Settleable Solids	0.5 ml/l	---
pH	within the range 6.0 to 9.0 at all times	---

*The limitations in this table apply to overflows caused by precipitation or equivalent snowmelt volumes less than the 10-year, 24-hour event, except where noted.

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Further, an operator will have to provide pH control for all storms, regardless of their size. Settleable solids were selected for regulation because pond performance during precipitation or increased flows due to snowmelt is much more consistent with regard to this parameter than for total suspended solids effluent levels. The alternate limits apply for facilities designed, constructed, operated, and maintained to contain a 10-year, 24-hour storm event. Otherwise, no relief from other effluent limitations will be granted. The operator shall have the burden of demonstrating to the appropriate authority that the prerequisites for the alternate limitations have been met. The exemption published 28 December 1979 (44 FR 76788) would be modified accordingly by this proposal.

Post Mining Discharges

Underground Mines

EPA, in evaluating the length of time that effluent limitations should remain in effect, determined that for underground mines the effluent limitations will remain in effect until the applicable performance bond has been released. This will ensure that pollution abatement will continue until effective sealing and reclamation practices have been instituted.

Surface Mines

The Agency has established limits on settleable solids and pH for reclamation areas as follows:

	Effluent Limitations	
Effluent Characteristic	Maximum for any one day	Average of daily values for 30 consecutive days shall not exceed
Settleable Solids	0.5 ml/l	----
pH	within the range 6.0 to 9.0 at all times	----

These limitations would apply to areas where regrading has been completed and revegetation commenced, and will extend through the release of the applicable reclamation bond.

BCT EFFLUENT LIMITATIONS

As discussed in Section I, the BCT limitations proposed by the Agency will be identical to the BPT limitations for conventional pollutants.

BAT EFFLUENT LIMITATIONS

Four subcategories were established for promulgation of effluent limitations based on the best available technology economically achievable (BAT): (1) preparation plants and associated areas; (2) acid mine drainage; (3) alkaline mine drainage; and (4) post mining discharges. The proposed limitations for acid mine drainage, post mining discharges at underground mines, and coal preparation plants and associated areas are based on neutralization and settling (if applicable in the case of preparation plants); those for alkaline drainage mines and reclamation areas are based on settling. For the coal mining industry, the BAT and BPT technologies are identical, so that the effluent limitations will be the same. The limitations guidelines appear in Table II-1. The modified BPT conditions will also apply for BAT, including the alternate limitations for rainfall.

As in the BPT promulgation, a variance will be permitted on a case-by-case basis to allow effluent pH to slightly exceed 9.0 to achieve the manganese limitation for those subcategories subject to manganese limitations.

NEW SOURCE PERFORMANCE STANDARDS

The proposed new source performance standards (NSPS) for the coal mining industry require achievement of pollutant levels based on the same technology proposed for BAT for each subcategory except preparation plants. In this case, a complete water recycle system fulfills the requirement for no discharge of wastewater pollutants, a demonstrated technology for these facilities. Limitations are summarized in Table II-2.

PRETREATMENT STANDARDS

Pretreatment standards are not proposed for the coal mining industry because there are no known existing situations in which such standards would be applicable. No indirect dischargers are known to exist in this category, nor are any anticipated.

Table II-1

EFFLUENT LIMITATIONS BASED ON BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BAT)

Subcategory and Effluent Characteristics	Effluent Limitations (mg/l)	
	Maximum for any one day	Average of daily values for 30 consecutive days shall not exceed
Preparation Plants and Associated Areas:		
Fe (total)	7.0	3.5
Mn* (total)	4.0	2.0
TSS	70	35
pH (units)	within the range 6.0 to 9.0 at all times	---
Acid Mine Drainage:		
Fe (total)	7.0	3.5
Mn (total)	4.0	2.0
TSS	70	35
pH (units)	within the range 6.0 to 9.0 at all times	---
Alkaline Mine Drainage:		
Fe (total)	7.0	3.5
TSS	70	35
pH (units)	within the range 6.0 to 9.0 at all times	---
Post Mining Discharges:		
Reclamation Areas (Surface)		
Settleable Solids	0.5 ml/l	---
pH (units)	within the range 6.0 to 9.0 at all times	---

Table II-1 (Continued)

EFFLUENT LIMITATIONS BASED ON BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BAT)

Subcategory and Effluent Characteristics	Effluent Limitations (mg/l)	
	Maximum for any one day	Average of daily values for 30 consecutive days shall not exceed
Underground Mines		
Fe (total)	7.0	3.5
Mn* (total)	4.0	2.0
TSS	70	35
pH (units)	within the range 6.0 to 9.0 at all times	---

---

*If raw wastewater is acidic prior to any treatment.

Table II-2

NEW SOURCE PERFORMANCE STANDARDS

Subcategory and Effluent Characteristics	Effluent Limitations (mg/l)	
	Maximum for any one day	Average of daily values for 30 consecutive days shall not exceed
Preparation Plants:		
Fe (total)	NO DISCHARGE OF WASTEWATER POLLUTANTS	
Mn (total)		
TSS		
pH (units)		
Associated Areas:		
Fe (total)	7.0	3.5
Mn (total)	4.0	2.0
TSS	70	35
pH (units)	within the range 6.0 to 9.0 at all times	
Acid Mine Drainage:		
Fe (total)	7.0	3.5
Mn (total)	4.0	2.0
TSS	70	35
pH (units)	within the range 6.0 to 9.0 at all times	---
Alkaline Mine Drainage:		
Fe (total)	7.0	3.5
TSS	70	35
pH (units)	within the range 6.0 to 9.0 at all times	---
Post Mining Discharges:		
Reclamation Areas (Surface)		
Settleable Solids	0.5 ml/l	---
pH (units)	within the range 6.0 to 9.0 at all times	---

Table II-2 (Continued)

NEW SOURCE PERFORMANCE STANDARDS

Subcategory and Effluent Characteristics	Effluent Limitations (mg/l)	
	Maximum for any one day	Average of daily values for 30 consecutive days shall not exceed
Underground Mines		
Fe (total)	7.0	3.5
Mn* (total)	4.0	2.0
TSS	75	35
pH (units)	within the range 6.0 to 9.0 at all times	

---

*If raw wastewater is acidic prior to any treatment.

BEST MANAGEMENT PRACTICES (BMP)

For both surface mining and the surface effects of underground mining, the Department of Interior's Office of Surface Mining (OSM) under the Surface Mining Control and Reclamation Act has broad authority to promulgate specific regulations governing water management associated with mining and reclamation operations (44 FR 15143-15178). The resulting standards effectively establish a BMP program. Therefore, it is not EPA's intention to propose BMPs for coal mining under the authority established in the Clean Water Act. Rather, the proposed effluent limitations and OSM's standards will provide a coherent and complementary framework for regulation of this industry. If, in the future, it becomes apparent that BMP's under the Clean Water Act are necessary to supplement OSM's program, EPA will propose them as appropriate.

SECTION III

INTRODUCTION

The purpose of this document is to provide support for the amendment of BPT regulations, the proposal and promulgation of effluent limitations guidelines for BAT and BCT, the establishment of NSPS, identification of pretreatment standards for existing sources (PSES), and identification of pretreatment standards for new sources (PSNS) under Sections 301, 304, 306, 307, and 501 of the Clean Water Act.

STATUTORY AUTHORITY

The regulations described in this document are proposed under the authority of Sections 301, 304, 306, 307, and 501 of the Clean Water Act (the Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C. 1251 et seq., as amended by the Clean Water Act of 1977, Public Law 95-217 (the "Act")). These regulations are also proposed in response to the Settlement Agreement in Natural Resources Defense Council, Inc., v. Train, 8 ERC 2120 (D.D.C. 1976), modified 9 March 1979, 12 ERC 1833, 1841.

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" [Section 101(a)]. By 1 July 1977, existing point source industrial dischargers were required to achieve "effluent limitations requiring the application of the best practicable control technology currently available" (BPT) [Section 301(b)(1)(A)]. Further, by 1 July 1983, these dischargers were required to achieve "effluent limitations requiring the application of the best available technology economically achievable (BAT) which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants" [Section 301(b)(2)(A)]. New industrial direct dischargers were required to comply with Section 306 new source performance standards (NSPS), based on best available demonstrated technology (BADT), and new and existing dischargers to publicly owned treatment works (POTWs) were subject to pretreatment standards under Sections 307(b) and (c) of the Act. While the requirements for direct dischargers were to be incorporated into National Pollution Discharge Elimination System (NPDES) permits issued under Section 402 of the Act, pretreatment standards were made enforceable directly against dischargers to POTWs (indirect dischargers). Table III-1 summarizes these levels of technologies, sources affected, and deadlines for promulgation and compliance.

Although Section 402(a)(1) of the 1972 Act authorized the setting of requirements for direct dischargers on a case-by-case basis, Congress intended that, for the most part, control requirements

Table III-1

THE FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972

Level of Technology	Section of Act	Sources Affected	Deadline for EPA for Promulgation	Deadline for Operator Compliance
BPT	301, 304	Existing sources	1 yr. after passage	July 1, 1977
BAT	301, 304	Existing sources	1 yr. after passage	July 1, 1983
BADT	306	New sources	1 1/3 yr. after passage	effective upon promulgation
PSES	307	Existing sources discharging to POTW	270 days after passage	no later than 3 years after promulgation
PSNS	307	New sources discharging to POTW	1 1/3 yrs. after passage	effective upon promulgation

would be based on regulations promulgated by the Administrator of EPA. Section 304(b) of the Act required the Administrator to promulgate regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of BPT and BAT. Moreover, Sections 304(c) and 306 of the Act required promulgation of regulations for NSPS, and Sections 304(f), 307(b), and 307(c) required promulgation of regulations for pretreatment standards. In addition to these regulations for designated industry categories, Section 307(a) of the Act required the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants. Finally, Section 501(a) of the Act authorized the Administrator to prescribe any additional regulations "necessary to carry out his functions" under the Act.

Under the deadlines contained in Table III-1, EPA (the Agency) was required to promulgate many of these standards by mid-year in 1973. The Agency was unable to meet this requirement, and, as a result, several environmental groups filed suit against EPA in 1974. EPA agreed to promulgate the remaining regulations and guidelines according to a court ordered schedule. See NRDC v. Train, ERC 1033 (520 Fed. 692, D.C. Cir. 1975).

In 1976, EPA was again sued because many of the regulations required by the Federal Water Pollution Control Act Amendments of 1972 had not been promulgated. In settlement of this lawsuit, EPA and the plaintiffs executed a "Settlement Agreement" which was approved by the Court. This Agreement required EPA to develop a program and adhere to a schedule for promulgating for 21 major industries BAT effluent limitations guidelines, pretreatment standards, and new source performance standards for 65 "priority" pollutants and classes of pollutants. See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified 9 March 1979.

On 27 December 1977, the President signed into law the Clean Water Act of 1977 (P.L. 95-217). Although this law makes several important changes in the federal water pollution control program, its most significant feature is its incorporation into the Act of several of the basic elements of the Settlement Agreement program for toxic pollution control. Sections 301(b)(2)(A) and 301(b)(2)(C) of the Act now require the achievement by 1 July 1984 of effluent limitations requiring application of BAT for toxic pollutants, including the 65 toxic pollutants and classes of pollutants which Congress declared toxic under Section 307(a) of the Act. Likewise, EPA's programs for new source performance standards and pretreatment standards are now aimed principally at toxic pollutant controls. Moreover, to strengthen the toxics control program, Congress added Section 304(e) to the Act, authorizing the Administrator to prescribe "best management practices" (BMPs) to prevent the release of toxic and hazardous pollutants from plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage associated with, or ancillary to, the manufacturing or treatment process.

In keeping with its emphasis on toxic pollutants, the Clean Water Act of 1977 also revised the control program for non-toxic pollutants. Instead of BAT for "conventional" pollutants identified under Section 304(a)(4) (including biochemical oxygen demand, suspended solids, fecal coliform, pH, and oil and grease), the new Section 301(b)(2)(e) requires achievement by 1 July 1984, of "effluent limitations requiring the application of the best conventional pollutant control technology" (BCT). The factors considered in assessing BCT for an industry include the costs of attaining a reduction in effluents and the effluent reduction benefits derived compared to the costs and effluent reduction benefits from the discharge of publicly owned treatment works [Section 304(b)(4)(B)]. For non-toxic, nonconventional pollutants, Sections 301(b)(2)(A) and (b)(2)(F) require achievement of BAT effluent limitations within three years after their establishment or 1 July 1984, whichever is later, but not later than 1 July 1987.

PRIOR EPA REGULATIONS

On 17 October 1975, EPA proposed regulations adding Part 434 to Title 40 of the Code of Federal Regulations (40 FR 48830). These regulations, with subsequent amendments, established effluent limitations guidelines based on the use of the best practicable control technology currently available (BPT) for existing sources in the coal mining point source category. These were followed, on 26 April 1977, by final BPT effluent limitations guidelines for this category (42 FR 21380).

On 19 September 1977, the Agency published proposed new source performance standards (NSPS) within this industrial category based on application of the best available demonstrated control technology (42 FR 46932). On 12 January 1979, EPA promulgated final NSPS for this industry (44 FR 2586).

Both the BPT and NSPS regulations contained an exemption from otherwise applicable requirements during and after catastrophic precipitation events. These storm exemptions were re-examined, subjected to further public comment, and ultimately revised on 28 December 1979 (44 FR 76788).

Moreover, the NSPS regulations contained a definition of "new source coal mine" which was challenged by petitioners in Pennsylvania Citizens Coalition et al. v. EPA. 14 ERC 1545 (3rd Cir. 1980). In response to the Court's decision in that case, the Agency amended its definition of a "new source coal mine" on 27 June 1980 (45 FR 43413).

RELATIONSHIP TO OTHER REGULATIONS

The coal mining industry has been subject to a variety of federal and state regulations during its history. The Surface Mining Control and Reclamation Act of 1977 (SMCRA-P.L. 95-87, 30 U.S.C. 1251-1279) established statutory authority for regulatory development with an Office of Surface Mining, Reclamation, and Enforcement (OSM) within the Department of the Interior (DOI). For both surface mining and the surface effects of underground mining, OSM has promulgated specific regulations governing water management associated with mining and reclamation operations (44 FR 15143). A number of these standards have been recently remanded as a result of litigation; OSM is now in the process of a new rulemaking. EPA and OSM are developing a memorandum of understanding (MOU) to consolidate the permit process (44 FR 55322) and integrate the NPDES system with OSM's permit system for Surface Coal Mining and Reclamation Operations (SCMROs). This should minimize duplication between agencies with similar goals. EPA and OSM will continue to work closely in establishing a comprehensive, efficient program for regulation of surface coal mining operations.

OVERVIEW OF THE INDUSTRY

The Standard Industrial Classification (SIC) Categories reviewed and discussed in this document include the following:

1. SIC 1111 Anthracite Mining,
2. SIC 1112 Anthracite Mining Services,
3. SIC 1211 Bituminous Coal and Lignite Mining, and
4. SIC 1213 Bituminous Coal and Lignite Mining Services.

The coal mining industry extracts and processes coal, a black, primarily organic substance formed from compressed layers of decaying organic matter millions of years ago. Depending upon the fixed carbon content, the volatile matter fraction, and the heating value, coals are classified by ranks generally as lignite, subbituminous, bituminous, and anthracite. The primary end uses of the material are for combustion in steam boilers or metallurgical coke ovens with a large potential market for coal conversion facilities in the synthetic fuels industry. The industry can be broadly classified into extraction (mining) and processing (preparation). The industry currently operates in 26 states; mines are located in Appalachia, the Midwest, the Great Plains, and the Mountain and Pacific regions. In 1978, 6,075 coal mining operations were active; 5,976 of these mines are located in the eastern part of the country, as opposed to 99 in the western United States. The western mines are characteristically newer and much larger than most eastern mines. In addition, there are currently about 650 coal preparation plants in the country. Through the year 1987, 404 new mines are projected; 243 will be located in the eastern U.S. and 161 will be located in the western U.S (1).

Total coal production in the U.S. in 1979 was 770,000,000 short tons (2). Because of the many political, environmental, and economic factors that impact the U.S. energy supply picture, projections for increases in domestic coal production are widely variable. Most estimates target production in 1985 at around one billion short tons per year. By 1990, this projected tonnage will increase to approximately 1.2 billion short tons per year (3, 4).

From the 1920's until 1978, underground mining has gradually declined from accounting for almost 100 percent of all coal production to 36 percent; conversely, surface mining has increased, bypassing underground mining in terms of total production of coal in the early 1970's. In 1978 surface mining accounted for 63 percent of all coal produced in the U.S. This rapid growth of surface mining was made possible by improved machinery and mining methods, the general geology of the coal fields, and the rapid expansion of the western surface mined coal fields.

The 6,075 mines in the U.S. are controlled by approximately 3,800 companies (1). The majority of these mines are small operations, with individual production less than 100,000 short tons per year. These small operations accounted for over 89 percent of the active mines in 1975; however, they accounted for less than 20 percent of coal production. In recent years, the trend has been toward larger mines and consolidation of mining companies (5).

SUMMARY OF METHODOLOGY

Analysis of the sources, levels, and applicable treatment processes for toxic, non-conventional, and conventional pollutants in coal mining wastewaters forms the basis for this study. To establish effluent limitations guidelines, a data collection program was initiated in 1976 to profile the coal mining industry. This data collection program will augment the data base previously developed for BPT requirements. The first step in the BAT review involved characterization of toxic compounds in coal mine wastewaters in accordance with the Settlement Agreement executed by NRDC and EPA in June of 1976. No general survey questionnaire under authority of Section 308 of the Clean Water Act was attempted at the outset of this study because over 6,000 mines are in active operation today. Therefore, representative mines to characterize the entire industry were selected for sampling. The sampling program was initiated in two phases--screening sampling and verification sampling. The screening program established the general characteristics of mine and preparation plant drainage.

After the screening sampling effort was well underway, verification sampling was initiated. This program entailed more extensive composite sampling with special regard for those priority pollutants identified from the screen sampling program. Levels of detected pollutants were quantified. The effluent characteristics were used to evaluate and, if necessary, modify the BPT subcategorization scheme. In addition, pollutants to be regulated for BAT and NSPS were identified.

The results of the screening and verification program were examined to determine pollution control needs. Several candidate treatment technologies were then identified to control pollutant discharges. The techniques identified for removal of organics include neutralization, aeration, ozonation, carbon adsorption, and sand filtration. A pilot treatment unit was assembled at the EPA Crown Mine Drainage Control site to test the above technologies on coal mine drainage. The primary focus of this treatability study was to quantify the removals of organic pollutants by the various control technologies.

A number of environmental control processes that reduce toxic and other metallic pollutants in mine drainage were also evaluated. A treatability study was performed by EPA's Office of Research and Development for metals removal achieved by lime neutralization, ion exchange, and reverse osmosis (6). Additionally, the Agency commissioned three treatability studies in 1979-80 to quantify removals of priority metals from acid mine drainage by the use of flocculant addition and granular media filtration.

Another important facet of this study is the development of costs associated with purchase, installation, and operation of treatment equipment. Cost curves were developed from model plants. These costs were verified by site visits to 17 facilities. At the facilities, site-specific cost data were collected. Actual costs were compared to model plant costs.

Additional data were collected to gain a more accurate profile of coal preparation plants, particularly in reference to water management practices and total recycle systems. To implement this effort, EPA, with the cooperation of the National Coal Association (NCA), disseminated a questionnaire to NCA member companies. Information gathered from the 152 respondents indicates that approximately 34 percent of the U.S. preparation plants are currently operating a total recycle system with diversion of storm water. Additionally, a classification scheme for different size plants with varying requirements for achievement of zero discharge was developed for costing purposes. Costs for retrofitting the industry for total water recycle were developed.

Report Organization

The Industry Profile, Section IV, includes background information on the history and geology of coal, production and other important statistics, mining techniques, and water use and management within the coal industry. This characterization of the industry will provide a foundation for analysis of water use and wastewater generation and treatment.

Section V, Wastewater Characterization and Industry Subcategorization, summarizes data collected on the levels of pollutants from a two phase sampling program. Twenty-three mines and facilities were visited during the screening phase; four sites from screening were revisited and five additional sites were sampled during the verification phase. This screening and verification program was conducted primarily to identify and quantify levels of toxic pollutants in coal mine wastewaters. The section also includes effluent data from 17 mines visited in the final segment of the BAT review, and EPA Regional data.

In Section VI, Selection of Pollutant Parameters, all 129 priority pollutants as well as the currently regulated parameters--TSS, pH, iron, and manganese--are discussed in light of their source, level, and treatability.

After selection of the pollutants to be regulated, a candidate list of treatment technologies to reduce or eliminate these parameters was prepared. The achievable effluent pollutant reductions are quantified, using results from previous and current EPA treatability studies as well as pilot studies conducted by other governmental agencies and industry. These control options and a review of water management practices are presented in Section VII, Treatment and Control Technology.

The processes that are technically suitable are then further analyzed according to their cost effectiveness, energy requirements, and secondary pollution potential. These factors are presented in Section VIII, Cost, Energy, and Non-Water Quality Issues. Cost information contained in this report was obtained from industry during plant visits, engineering firms, equipment suppliers, and from the literature. The information obtained was used to develop capital and operating costs for each treatment and control method. Where data were lacking, costs were developed from knowledge of equipment required, processes employed, and construction and maintenance requirements. An economic analysis to determine the impact on the industry of installing the technically feasible treatment option(s) was conducted using the costs developed herein. This assessment is reported separately by EPA.

Section IX details the amendments made to the BPT regulation. Proposed BAT options are presented in Section X. All data obtained were evaluated to determine what levels of treatment constituted reasonable alternatives for consideration as the "best available technology economically achievable" (BAT). Several factors were considered in identifying technologies. These included the age of equipment and facilities involved, the process employed, engineering aspects of the application of various types of control techniques or process changes, the cost of achieving effluent reduction, non-water quality environmental impacts, and energy requirements. Efforts were also made to determine the feasibility of transfer of technology from subcategory to subcategory, other categories, and other industries where similar effluent problems might occur. Consideration of the technologies was not limited to those presently employed in the industry, but included those processes in pilot plant or laboratory research stages. This section includes a discussion of the best management practices (BMP) program.

Section XI examines the applicability of the best conventional pollutant control technology (BCT) for the coal mining industry.

New source performance standards (NSPS), which are discussed in Section XII, are selected based on the best available demonstrated technology (BADT). The best demonstrated process changes, in-plant controls, and end-of-pipe treatment technologies which reduce pollution to a minimum are considered.

Section XIII summarizes the rationale for not proposing pretreatment regulations for this industry.

SECTION IV

INDUSTRY PROFILE

INTRODUCTION

The purpose of this section is to profile the U.S. coal mining industry and its water usage according to a number of descriptive parameters. The origin and chemistry of coal are described prior to a discussion of water use within the mining and preparation segments of the industry. The history, future, and location and production aspects of coal mining are then presented. The section concludes with a discussion of industry processes and methods.

ORIGIN AND CHEMISTRY OF COAL

Origin

Coal had its origin in the accumulation and physical and chemical alteration of vegetation. More precisely, conditions necessary for the accumulation of peat and subsequent formation of coal are as follows:

1. Swamp or marsh environment and climate favorable to plant growth.

2. Some subsidence of the area during accumulation of vegetal debris, or compaction of deposited plant material, permitting further accumulation.

3. Sufficiently wet conditions to permit exclusion of air from much of the vegetal material before it decays, and sufficiently rapid accumulation to thwart bacterial action, even within the swamp water. The acidity of this water normally prevents bacterial action at a few inches or a few feet below the water level in the swamp.

4. Proximity to the sea or a sinking area so that vegetal material can be buried by sediments when the sea level rises or the land subsides.

5. Site of accumulation such that removal by erosion does not subsequently occur.

As peat accumulated, the weight of the top layers of peat compacted the lower layers, primarily by squeezing out large amounts of water. Various chemical effects and bacterial action on the vegetal debris also took place in the swamp environment. Burial by sediments, physical-chemical effects associated with the changed environment, and loss of water and volatile materials

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resulted in formation of lignite, the earliest stage in the formation of coal.

With increasingly deeper burial, pressure continues to compress the lignite, and the increase in heat associated with the increasing depth of burial will further devolatize the coal-forming materials. The rank (Table IV-1) of the coal became progressively higher, rising from lignite through subbituminous, bituminous, semianthracite, and anthracite to meta-anthracite. Estimates indicate that about three to seven feet of reasonably compacted plant material is required to form one foot of bituminous coal (1).

Chemistry

The chemical constituents in coal determine its characteristics. These characteristics depend on:

1. The type of vegetation from which the coal was originally formed;

2. The pressure to which the decaying vegetation was subjected;

3. The foreign matter, whether wind or waterborne, that was deposited on the decaying vegetation while it was being converted into coal, or the foreign matter that infiltrated while in solution after the coal was formed; and

4. The heat to which the decaying vegetation was subjected.

The environmental conditions under which the coal was formed are the primary determinants of the coal's chemical and physical properties. For instance, coals in the Illinois seams were inundated by marine water soon after formation, imparting a high concentration of sulfur. Low-sulfur coals are often found in areas where fresh water conditions prevailed.

As codified by the International Committee for Coal Petrography, the ultimate microscopic constituents of coal are a series of macerals, which are characterized by their appearance, chemical composition, and optical properties, and which can, in most cases, be traced to specific components of the plant debris from which the coal formed. Macerals are further grouped by appearance into three major maceral groups. Coal macerals and maceral groups recognized by the International Committee for Coal Petrography are presented in Table IV-2.

Coal, in general, has a lamellated (thin-layered) structure comprised of both organic and mineral matter. Inherent minerals (minerals confined within the coal structure) are primarily iron,

Table IV-1

CLASSIFICATION OF COALS BY RANK

Class	Group	Fixed Carbon Limits, % (Dry Mineral-Matter-Free Basis) Equal or Greater Than	Fixed Carbon Limits, % (Dry Mineral-Matter-Free Basis) Less Than	Volatile Matter Limits, % (Dry, Mineral-Matter-Free Basis) Greater Than	Volatile Matter Limits, % (Dry, Mineral-Matter-Free Basis) Equal or Less Than	Calorific Value Limits, Btu per Lb (Moisture,[2] Mineral-Matter-Free Basis) Equal or Greater Than	Calorific Value Limits, Btu per Lb (Moisture,[2] Mineral-Matter-Free Basis) Less Than	Agglomerating Character
I. Anthracitic	1. Meta-anthracite	98	..	..	2	..	..	Nonagglomerating
	2. Anthracite	92	98	2	8	..	..	
	3. Semianthracite[3]	86	92	8	14	..	..	
II. Bituminous	1. Low-volatile bituminous coal	78	86	14	22	..	..	Commonly agglomerating[5]
	2. Medium-volatile bituminous coal	69	78	22	31	..	..	
	3. High-volatile A bituminous coal	..	69	31	..	14,000[4]	..	
	4. High-volatile B bituminous coal	..	..	..	..	13,000[4]	14,000	
	5. High-volatile C bituminous coal	..	..	..	..	11,500	13,000	
						10,500	11,500	Agglomerating
III. Subbituminous	1. Subbituminous A coal	..	..	..	..	10,500	11,500	Nonagglomerating
	2. Subbituminous B coal	..	..	..	..	9,500	10,500	
	3. Subbituminous C coal	..	..	..	..	8,300	9,500	
IV. Lignitic	1. Lignite A	..	..	..	..	6,300	8,300	
	2. Lignite B	..	..	..	..	..	6,300	

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(1) This classification does not include a few coals, principally nonbanded varieties, which have unusual physical and chemical properties and which come within the limits of fixed carbon or calorific value of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48 percent dry, mineral-matter-free fixed carbon or have more than 15,500 moisture, mineral-matter-free Btu per lb.

(2) Moisture refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

(3) If agglomerating, classify in low-volatile group of the bituminous coal.

(4) Coals having 69 percent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.

(5) It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in high-volatile C bituminous group.

Source: American Society for Testing and Materials, D388

Table IV-2

COAL MACERALS AND MACERAL GROUPS RECOGNIZED BY THE INTERNATIONAL COMMITTEE FOR COAL PETROGRAPHY

Maceral Group	Symbol	Maceral	Composed of or Derived From
Vitrinite	V	Collinite	Humic gels
		Tellinite	Wood, bark, and cortical tissue
		Vitrodetrinite[a]	
Exinite	E	Sporinite	Fungal and other spores
		Cutinite	Leaf cuticles
		Resinite	Resin bodies and waxes
		Alginite	Algal remains
		Liptodetrinite[a]	
Inertinite	I	Micrinite	Unspecified detrital matter, <10 m
		Macrinite[b]	Similar, but 10-100 m grains
		Semifusinite	
		Fusinite	"Carbonized" woody tissues
		Sclerotinite	
		Inertodetrinite[a]	

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[a] These terms are applied to small entities that, because of their reflectivity, must be assigned to this maceral group, but that cannot be unequivocally identified with any particular maceral within the group. Thus, vitrodetrinite is used to designate a maceral when it is not possible to distinguish between collinite and tellinite, and liptodetrinite is used where, e.g., it is impossible to differentiate between sporinite and cutinite on morphological grounds.

[b] This is sometimes also referred to as massive micrinite.

Source: (2)

phosphorous, sulfur, calcium, potassium, and magnesium; these comprise less than two percent (by weight) of the coal (3). A great many trace elements are also found in coal; these are shown in Table IV-3. Though coal is primarily organic, specific information regarding organic constituents is not readily available, excepting ultimate analyses.

Extraneous coal mineral matter (ash) is matter that was deposited simultaneously with the peat, or through cracks following peat consolidation. Ash content generally ranges from 3 to 20 percent (by weight) and averages 10 percent. Major constituents are shown in Table IV-4. The chemical composition of coal ash varies greatly. It is a mixture of silica (SiO_2) and alumina (Al_2O_3), which comes from sand, clay, slate and shale; iron oxide (Fe_2O_3), from pyrite and marcasite; magnesia (MgO) and lime (CaO), from gypsum and limestone; the alkalies, sodium oxide and potassium oxide (Na_2O and K_2O); phosphorus pentoxide (P_2O_5); plus trace amounts of antimony, arsenic, barium, beryllium, boron, cadmium, cobalt, copper, germanium, gold, lead, manganese, mercury, platinum, scandium, selenium, silver, tin, titanium, uranium, vanadium, yttrium, and zinc.

Inorganic sulfur, usually in the form of pyrite, is the constituent in coal that often results in the formation of acid waters. Such effluents develop where the inorganic (pyritic) sulfur in exposed coal is oxidized by air to SO_2 and a variety of iron sulfates. These constituents then partially combine with the hydrogen in water to produce sulfuric acid (H_2SO_4), which leaches additional metals. It is important to note that organically bound sulfur, generally believed to be in complex combination with the organic constituents of coal, does not participate in these oxidation processes, and that coals containing little pyrite consequently pose no environmental hazards from acid mine waters or runoffs even if their total sulfur contents are substantial.

Sulfur infiltrated coal in a number of ways. Sulfur was usually present in the swamp, and some of it was taken up by the plants. Under certain conditions, sulfur in the peat swamp was converted to the mineral pyrite. Sulfur also appears to have been introduced into the coal seam after the peat had been converted to coal. This is evident by the appearance of pyrite coatings on vertical fracture surfaces in the seam. Much of the pyrite present occurs as very small crystalline grains intimately mixed with the organic constituents of coal. The origin of sulfur in large concretions, nodules, lenses and bands, and filling in porous layers of coal, is only partially understood, but the relationship between the high-sulfur content of coals and the sediments immediately overlying the coals that were clearly deposited in a marine environment strongly suggests that seawater was the source of much of the sulfur found in coal.

Table IV-3

TRACE INORGANIC ELEMENTS IN COAL

Trace Inorganic Elements
(about 0.1% or less, on ash)

Beryllium
Fluorine
Arsenic
Selenium
Cadmium
Mercury
Lead
Boron
Vanadium
Chromium
Cobalt
Nickel
Copper
Zinc
Gallium
Germanium
Tin
Yttrium
Lanthanum
Uranium
Lithium
Scandium
Manganese
Strontium
Zirconium
Barium
Ytterbium
Bismuth

Source: (2)

Table IV-4

MAJOR INORGANIC CONSTITUENTS OF COAL, ASH PORTION

Major Inorganic Constituent	Forms in Coal	
Silicon	Silicates and sand	
Aluminum	Aluminum in combination with silica	
Iron	Pyrite and marcasite (sulfide)	
	Ferrous oxide	
	Ferrous carbonate	
	Ferrous sulfate	
	Ferric oxide	In small quantities
	Ferric sulfate	
	"Organic" iron	
	Iron silicates	
Calcium	Lime, carbonate, sulfate, silicates	
Magnesium	Carbonates, silicates	In small quantities
Sodium and potassium	Silicates, carbonates, chlorides	
Manganese	Carbonates, silicates	
Sulfur (inorganic)	Pyrite and marcasite	
	Ferrous sulfate	
	Ferric sulfate	In small quantities
	Calcium sulfate	
Phosphorus	Phosphates	

Source: (2)

INDUSTRY WATER USE

Coal Mining

Water usage in the coal mining industry is different than in other major industries for a number of reasons. First, water is a hindrance to operation of strip and underground mining machinery. Second, water is used in the mining of coal primarily for dust suppression (i.e., haulroads, continuous miners, conveyor belts, coal stockpiles in some cases, etc.) and equipment cooling. Third, coal mines often occupy hundreds of acres of land subject to a high amount of precipitation. Therefore, pollution abatement must be approached differently, with reliance on operating and management practices for source control as well as end-of-pipe treatment technologies.

Water is also used to a very limited extent for irrigation of reclaimed lands. In some areas with extremely low precipitation, irrigation research is being conducted on an experimental basis by the U.S. Forest Service, using the sprinkler and drip methods. It appears doubtful, however, that irrigation on an extensive scale, and as a viable reclamation measure, is going to be practicable (4). Water entering mine areas because of precipitation, ground water infiltration, and surface runoff is a hindrance; removal of water from the active mining area is required at most mines to ensure the continuity, efficiency, and safety of the mining operation. Water infiltration is generally less severe in the semiarid west, unless the mine is located within a major aquifer.

In this study, all flow data available on mine drainage were assembled to determine whether or not flow of wastewater could be correlated with production. These data came from three sources: the BPT development document; a survey by Bituminous Coal Research, Inc.; and the screening phase of the BAT study. The data show that water volume (or flow) encountered during the coal mining operation cannot be related to coal production (see Figure IV-1), nor can it be expressed in the classic waste management terms of volume per weight of product. There are a number of variables that preclude such a relationship, including climatology, location of aquifers, amount of disturbed acreage, characteristics of individual watersheds, and rate of coal extraction.

Flows from acid and alkaline mines, and surface and underground mines, were examined for significant statistical differences. The data indicate no statistical difference in the amount of water pumped by various mines based on the factors listed above. Therefore, all mines were classed together and plotted against production to identify any correlation (see Figure IV-1). A regression analysis performed on this data shows no correlation.

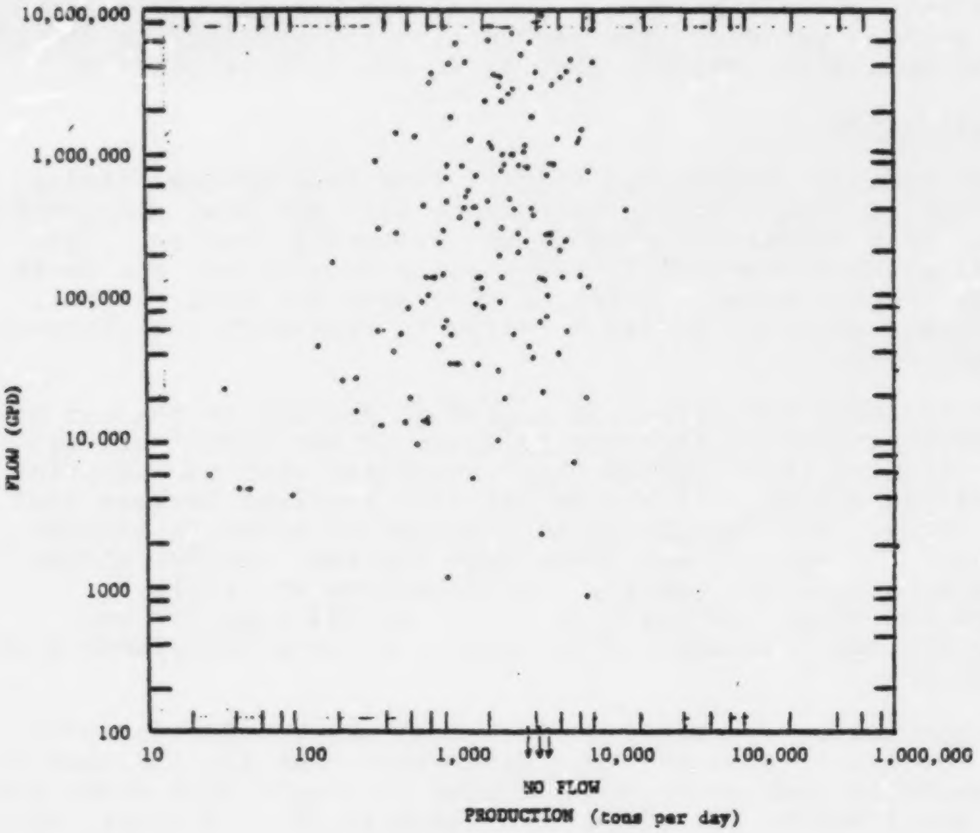

Figure IV-1

SCATTER DIAGRAM OF COAL MINE PRODUCTION AND MINE DRAINAGE

Source: (5)

The correlation coefficient (r^2) for 140 coal mines is 0.18 with a slope for the least square line of 0.04.

A distribution curve for the volume of water pumped by bituminous and lignite mines is presented in Figure IV-2. Eighty percent of the flow volumes fall between 7,000 gallons per day (GPD) and 4.5 million gallons per day. The median flow (50 percent) is 250,000 GPD. The mean flow, 995,000 GPD, is at the 75th percentile.

Coal Preparation

Water use in coal preparation differs from that in coal mining. Here, water is intentionally introduced into the coal preparation process. Unit operations such as wet screening, tables, jigs, cyclones, gravity separation, heavy media separation, and froth flotation require water. Water is also used for dust control, for equipment cooling, and as a medium to transport coal between unit operations.

The coal industry has witnessed a gradual decline in the use of dry methods of coal preparation in favor of wet techniques (6). Present cleaning technologies were introduced with the adoption of mechanized mining, which does not differentiate between coal and impurities, and results in an increase of fines in run-of-mine coal. The need to wet clean coal has been further stimulated by more explicit quality specifications by utility customers and other consumers of coal. As the need for wet cleaning of coal increased, water use in preparation plants also increased (6).

A major portion of the water used in coal preparation is recirculated because of economic considerations; that is, the need to obtain suitable feed water and the need to comply with state and federal requirements for effluent discharges (6). However, there usually are emergency spillways which allow discharges during rainstorms or equipment breakdowns, etc. Many preparation plants are designed to operate on a closed water system as a matter of economics and to help meet water quality requirements. However, a need sometimes arises for a blowdown or purge in a total recycle system to reduce dissolved solids. Water usages from new preparation plant designs are presented in Table IV-5 and are compared with water usages from preparation plants (ranging from 3 to 41 years in age) visited in this study. In new closed-circuit plant designs (indicated by *), the data indicate that the amount of water used in the beneficiation process increases with the level of cleaning, or the amount of fine coal cleaning. However, the data do not establish any relationship between amount of coal cleaned and volume of water discharged, nor does it establish any industry-wide relationship between amount of water used and level of cleaning for older plants.

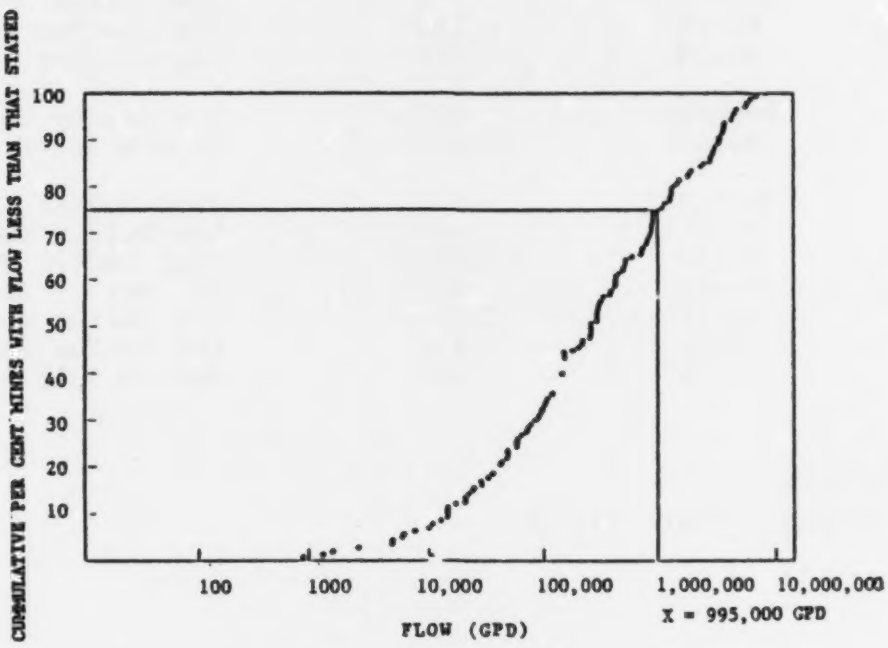

Figure IV- 2
FLOW DISTRIBUTION OF COAL MINES

Source: (5)

Table IV-5

WATER USE IN PREPARATION PLANTS BY LEVEL OF CLEANING AND TYPE OF COAL CLEANED

Level of Cleaning	Plant	Amount of Water Circulated per ton of Coal Cleaned, gal/ton	Type of Coal Cleaned
2	Bechtel*	112	Low Sulfur Eastern
	NC-10	1,190	High Sulfur Eastern
	NC-22	360	High Sulfur Eastern
3	Bechtel*	327	Low Sulfur Western
	NC-20	1,800	Medium Sulfur Eastern
4	Bechtel*	500	High Sulfur Eastern
	NC-3	483	Low Sulfur Western
	NC-14	3,050	High Sulfur Eastern
	NC-16	480	Low Sulfur Eastern
	NC-11	2,000	Low Sulfur Eastern
	NC-15	850	Low Sulfur Eastern
	NC-18	480	Medium Sulfur Eastern

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* New closed-circuit design

Source: (7)

HISTORY

Coal was first commercially mined in America in 1750, from the James River coal field near Richmond, Virginia. However, coal was not widely utilized until well into the 19th century because abundant forests supplied nearly all of the needed fuel. Total anthracite and bituminous coal consumption was only 98,000 metric tons (108,000 short tons) in 1800. Thereafter, consumption gradually increased until it superseded wood for the first time in 1840, after which coal mining became increasingly more important due to the development of railroads, steel mills, and other large consumers of fuel. After the Civil War, industrial development grew very rapidly, causing coal consumption to reach 181 million metric tons (200 million short tons) annually by 1900 and 454 million metric tons (500 million short tons) by 1910. Bituminous and lignite production temporarily peaked at 572 million metric tons (630 million short tons) in 1947, falling off to 356 million metric tons (392 million short tons) in 1954, and finally surpassing the 1947 high when 588 million metric tons (648 million short tons) were produced in 1975. In 1979, a new record for coal production was achieved by 770,000,000 short tons. Figure IV-3 shows U.S. consumption of coal by end-use sector.

In the early 1800's, anthracite production was greater and more important than bituminous coal, but, by 1870, anthracite and bituminous production were equal, and by 1901, bituminous production was four times greater. Total anthracite production continued to increase, however, until it peaked at 90.3 million metric tons (99.6 million short tons) annually during the World War I period (1917). Thereafter, its steady decline has lowered its production to 4.6 million metric tons (5.0 million short tons) for 1978. Anthracite's early popularity can be attributed to its high quality, use by the railroads, and proximity to major population centers where its clean-burning characteristics made it a favorite for space heating. The steady decline of the use of anthracite was caused by the high production of more convenient and cheaper natural gas, oil, and bituminous stoker coal. Table IV-6 and Figure IV-4 portray the history of anthracite coal production in the United States.

Surface Mining

Coal was first extracted by surface methods; however, the development of surface mining techniques was insignificant until around 1910 when steam-powered shovels were developed. Initially, truck-mounted shovels were used, but they only had a swing of 180°. Later, a wood frame, 360° shovel was built, and from then on the development of surface mining was rapid. By the 1930's, rail-mounted shovels were being replaced by those mounted on crawler tracks (i.e., dozer-type tracks), while steam power

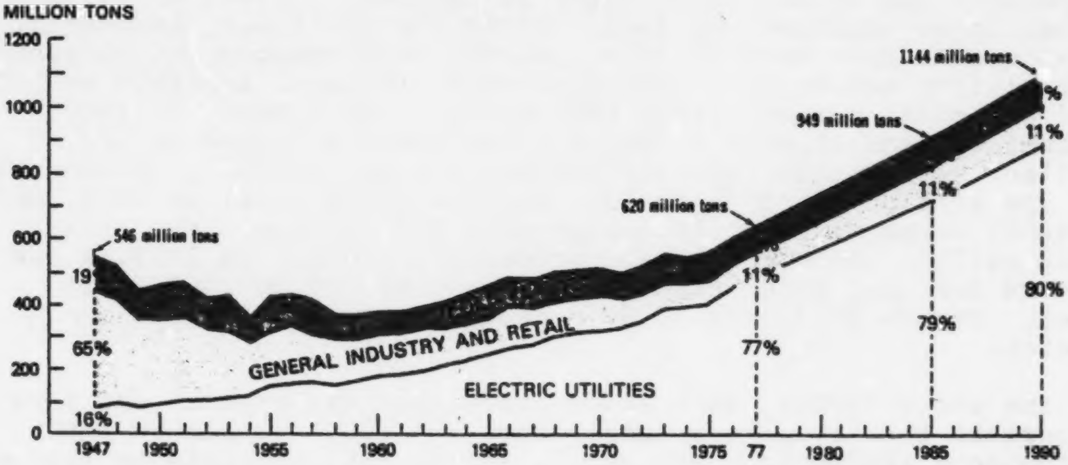


Figure IV-3
U.S. CONSUMPTION OF COAL BY END-USE SECTOR

Note: Percentage figures represent percent shares of total consumption.

Source: (8)

Table IV-6

HISTORY OF U.S. ANTHRACITE PRODUCTION

Year	Production (kkg - 10^6)[1]
1890	42.156
1900	52.043
1910	76.644
1920	81.282
1930	62.945
1940	46.706
1950	39.986
1960	17.071
1970	8.826
1975	5.628
1976	5.650
1977	4.591
1978	4.569

(1) Multiply by 1.1023 to obtain short (English) tons.

Sources: Years 1890-1976: (9)
1977-1978: (10)

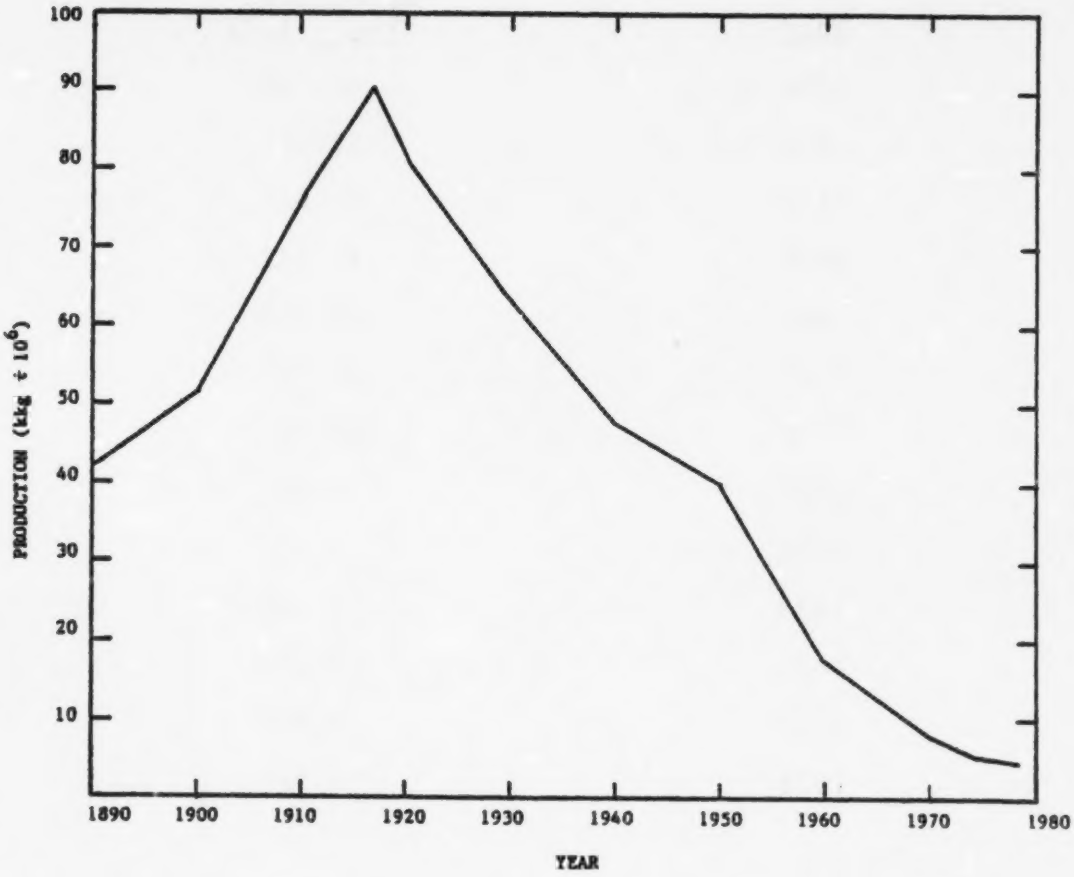


Figure IV-4
HISTORY OF U.S. ANTHRACITE PRODUCTION

Source: (11)

was being replaced by electric. During this same period, track haulage of coal with small side-dump cars were replaced by trucks.

These developments helped spur a steady increase in surface mine production for almost every year since 1920. In 1978, surface mine production comprised 63 percent of total U.S. production. This rapid growth was also made possible by constantly improving machinery and mining methods and by the general geology of the coal fields. Contour strip mining was first applied in the Appalachian fields where a combination of surface topography and coal beds frequently presented sizable areas along the outcrop (where the coal seam contacts the surface) with low overburden (dirt and rock material covering the coal) depth. In Ohio, the Midwest, North Dakota, and the Rocky Mountain states, large coal mining areas exist in gently rolling or nearly flat terrain; therefore, area strip mining methods are preferred to contour stripping. This condition helped promote high output mines which utilize even larger and more efficient draglines, shovels, end loaders, truck drills, and other auxiliary equipment. One of the most recent developments has been the use of wheeled front-end loaders for loading both coal and overburden. Hydraulic shovels are also being utilized more frequently. Bucket-wheel excavators are in use where conditions permit. Wheeled tractor scrapers are finding more and more acceptance for overburden removal. Numerous other new surface mining techniques and equipment are being studied; for example, continuous excavating machines that can increase overburden removal rates.

Underground Mining

Coal was initially mined by hand using a pick and bar, then shoveled into baskets or wheelbarrows. This progressed into cars drawn over wood planks, cars drawn over iron straps, and eventually cars drawn over rails by dogs or horses. Black powder was introduced to blast down the coal while undercutting, side-cutting, and drilling were still done by hand. Other developments during the 18th and 19th centuries which aided mining included: invention of the steam engine in 1775 to pump water out of the mine, making it possible for mines to go deeper; development of the first steam locomotive in 1814, leading to surface rail transportation of coal; and development of the first electric locomotive in 1883, leading to underground rail transportation of coal. Earliest full mechanization began in the 1920's when loading machines were successfully utilized in a number of mines. Rubber-tired shuttle cars were introduced in the 1930's, leading to rapid conversion of track-mounted loaders and cutters to off-track types. After World War II, tungsten carbide bits were introduced, thereby greatly improving the performance of cutting machines; continuous mining machines started making inroads in 1948; and roof bolting (installation of long bolts to stabilize the mine roof) became feasible, a significant development that resulted in higher productivity and increased safety.

Although longwall mining has been used extensively in Europe since the early 1900's, this technique became increasingly important in the United States only after the development of hydraulic, self-propelled roof jacks.

The growth and history of certain facets of the U.S. bituminous coal mining industry can be seen in Table IV-7 and Figures IV-5 through IV-11.

Transportation

Transportation costs are often a significant part of the overall cost of mining coal, especially if long distances are involved. For example, the rail cost of shipping coal from Gillette, Wyoming to Houston, Texas, a distance of 1,700 miles, is \$15.60 per short ton, whereas the f.o.b. mine value is only \$6.50 per short ton. This totals \$22.10 per short ton delivered (12).

Locks and dams were built on a number of rivers beginning about 1845, leading to a considerable increase in the development of river transportation.

Trucking of coal has become more important over the last 30 years if relatively short distances are involved, even though the cost per ton-mile is generally higher than for other means of shipment. It is practical where railroad facilities do not exist or where rail cannot be economically justified. High-tonnage conveyor systems are also used to move coal from mine to plant in certain situations.

Railroads have remained competitive by changing to unit-train shipments of coal. The unit train system moves approximately 9,000 metric tons (10,000 short tons) of coal directly from mine to customer and features high loading and unloading rates.

The effort to ship coal more economically from mine to powerplant resulted in the successful operation of the first coal pipeline for over six years (after which, in this case, rail transportation became more economical due to unit-train shipment), moving 1.13 million metric tons (1.25 million short tons) of Ohio coal annually over a distance of 100 miles. A more recently constructed coal slurry pipeline is operating in Arizona and is designed to transport 5.0 million metric tons (5.5 million short tons) annually from mine to a powerplant over a distance of 273 miles.

Table IV-7 (Part 1 of 3)

GROWTH OF THE BITUMINOUS AND LIGNITE COAL MINING INDUSTRY IN THE UNITED STATES

Year	Total Production ($kkg \div 10^6$)
1800	0.1
1900	181.4
1910	453.6
1920	515.9
1925	471.8
1930	424.1
1935	337.8
1940	418.0
1945	524.0
1950	468.4
1955	421.5
1960	376.9
1965	464.6
1966	484.3
1967	501.3
1968	494.6
1969	508.5
1970	547.0
1971	500.9
1972	540.1
1973	536.1
1974	547.4
1975	588.3
1976	615.7
1977	627.2
1978	593.1
1979	770.0*
1983	804.7
1985	905.0
1990	1,088.6[5]

Table IV-7 (Part 2 of 3)

GROWTH OF THE BITUMINOUS AND LIGNITE COAL MINING INDUSTRY IN THE UNITED STATES

Year	Value ($ + 10^6)	Average Price f.o.b. Mines ($/kkg)[a]	Number of Mines	Production Surface Methods (kkg + 10^6)	Production Surface Methods (%)	Production Underground Methods (kkg + 10^6)	Production Underground Methods (%)	Underground Production: Mined by Continuous Mining Machines (%)	Underground Production: Mechanically Loaded (%)	Average Number of Employees Working Daily: Total	Productivity (kkg/man-day)[a]: Total
1920	2,130	4.13	8,921	7.5	1.5	508.2	98.5			639,547	3.63
1925	1,060	2.25	7,144	15.1	3.2	456.7	96.8		1.2	588,493	4.10
1930	795	1.87	5,891	18.2	4.3	405.9	95.7		10.5	493,202	4.59
1935	658	1.95	6,315	21.6	6.4	316.2	93.6		13.5	462,403	4.08
1940	879	2.11	6,324	39.3	9.4	378.7	90.6		35.4	439,075	4.71
1945	1,768	3.37	7,033	99.6	19.0	424.4	81.0		56.1	383,100	5.24
1950	2,500	5.34	9,429	111.9	23.9	356.5	76.1	1.2	69.4	415,532	6.14
1955	2,092	4.96	7,856	104.5	24.8	317.0	73.9	8.0	84.6	225,093	8.93
1960	1,950	5.17	7,865	111.2	29.5	265.7	68.6	27.4	86.3	169,400	11.64
1965	2,276	4.89	7,228	150.1	32.3	314.5	64.9	42.7	89.2	133,732	15.89
1966	2,421	5.00	6,749	163.2	33.7	321.1	63.4	45.8	91.7	131,752	16.80
1967	2,555	5.09	5,873	169.9	33.9	331.4	63.1	47.4[b]	94.5	131,523	17.39
1968	2,546	5.15	5,327	168.7	34.1	325.9	63.1	47.6[b]	95.7	127,894	17.57
1969	2,796	5.50	5,118	179.0	35.2	329.5	61.9	49.7[b]	96.6	124,532	18.05
1970	3,773	6.90	5,601	221.5	40.5	325.5	56.2	50.1[b]	97.2	140,140	17.09
1971	3,905	7.79	5,149	234.9	46.9	266.0	50.0	55.4[b]	98.2	145,664	16.35
1972	4,562	8.44	4,879	250.1	46.3	290.0	51.1	58.7[b]	99.0	149,265	16.09
1973	4,976	9.28	4,650	249.8	46.6	286.3	51.0	na	99.2	157,800	15.20
1974	9,502	17.36	5,247	295.6	54.0	251.8	46.0			166,701	15.94
1975	12,472	21.20	6,168	322.4	54.8	265.9	45.2			189,880	13.37
1976	13,189	21.42	6,161	348.5	56.6	267.2	43.4			202,280	13.12
1977	13,709	21.86	6,200	387.0	61.7	240.2	38.3			214,777	13.37
1978	14,645	24.69	6,075	373.1	62.9	220.0	37.1			221,000	12.94

Table IV-7 (Part 3 of 3)

GROWTH OF THE BITUMINOUS AND LIGNITE COAL MINING INDUSTRY IN THE UNITED STATES

Footnotes:

(1) Multiply by 1.1023 to obtain short (English) tons $\div 10^6$.

(2) Multiply by 0.9072 to obtain $/short ton.

(3) Multiply by 0.9072 to obtain short tons/man-day.

(4) Mined by longwall machines; 1967, 0.9%; 1968, 1.3%; 1969, 1.8%; 1970, 2.1%; 1971, 2.4%; 1972, 2.6%; 1978, 5% (90 longwalls).

(5) NCA estimates that the national goal of 1.1 billion metric tons (1.2 billion short tons) annual coal production by 1985 will not be achieved until 1990.

* Estimated

Note: 1 kkg = 1,000 kilograms = 1 metric ton

Sources:	Years 1800, 1900, 1910:	(1)
	Years 1920 - 1978:	(13)
	Years 1979, 1983, 1990:	(14), (estimated by NCA)
	Year 1985:	U.S. Bureau of Mines

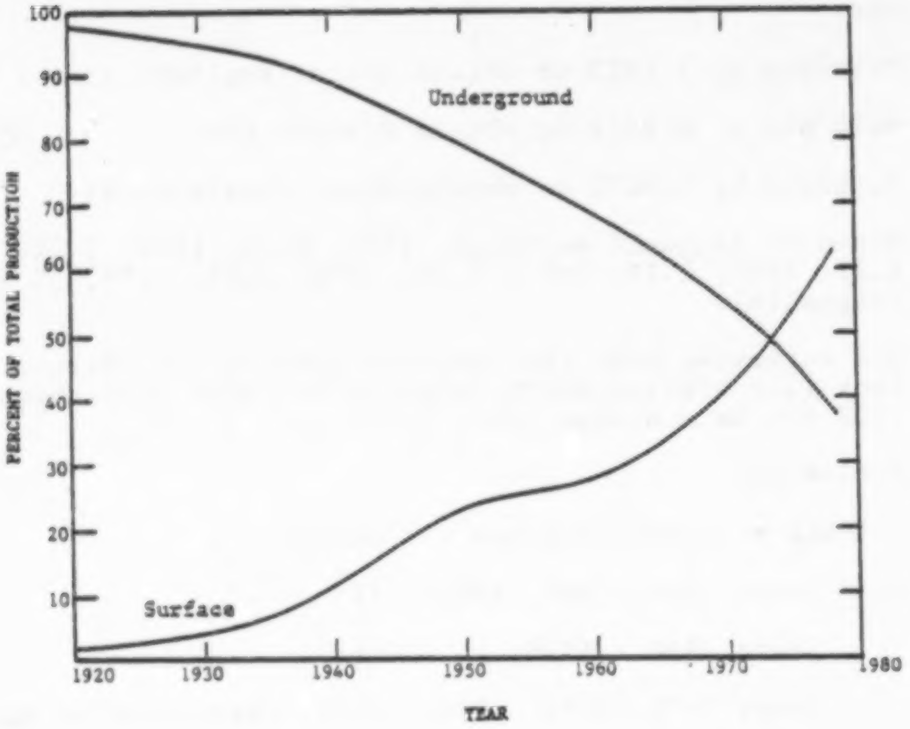


Figure IV- 5
PRODUCTION: SURFACE METHODS VERSUS UNDERGROUND METHODS

Source: 1979 Keystone Coal Industry Data

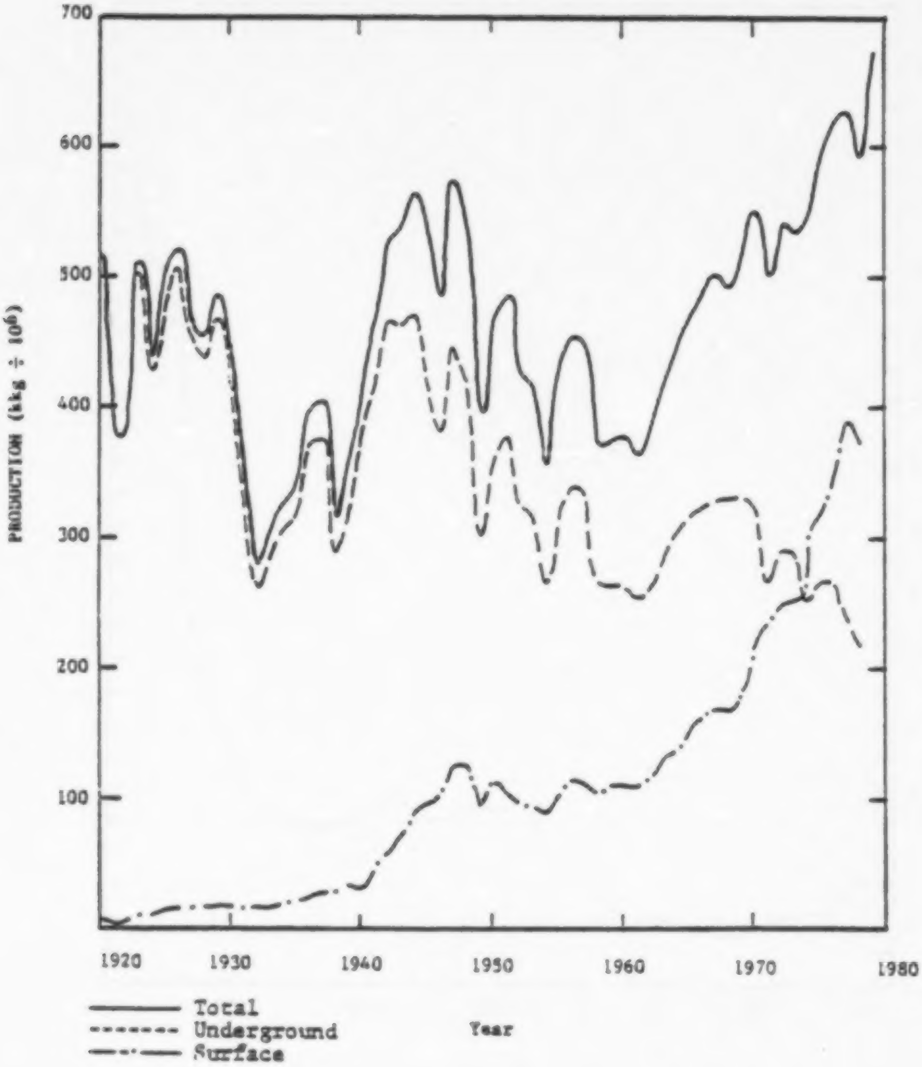


Figure IV-6
HISTORY OF BITUMINOUS AND LIGNITE
COAL PRODUCTION

Source: 1979 Keystone Coal Industry Data

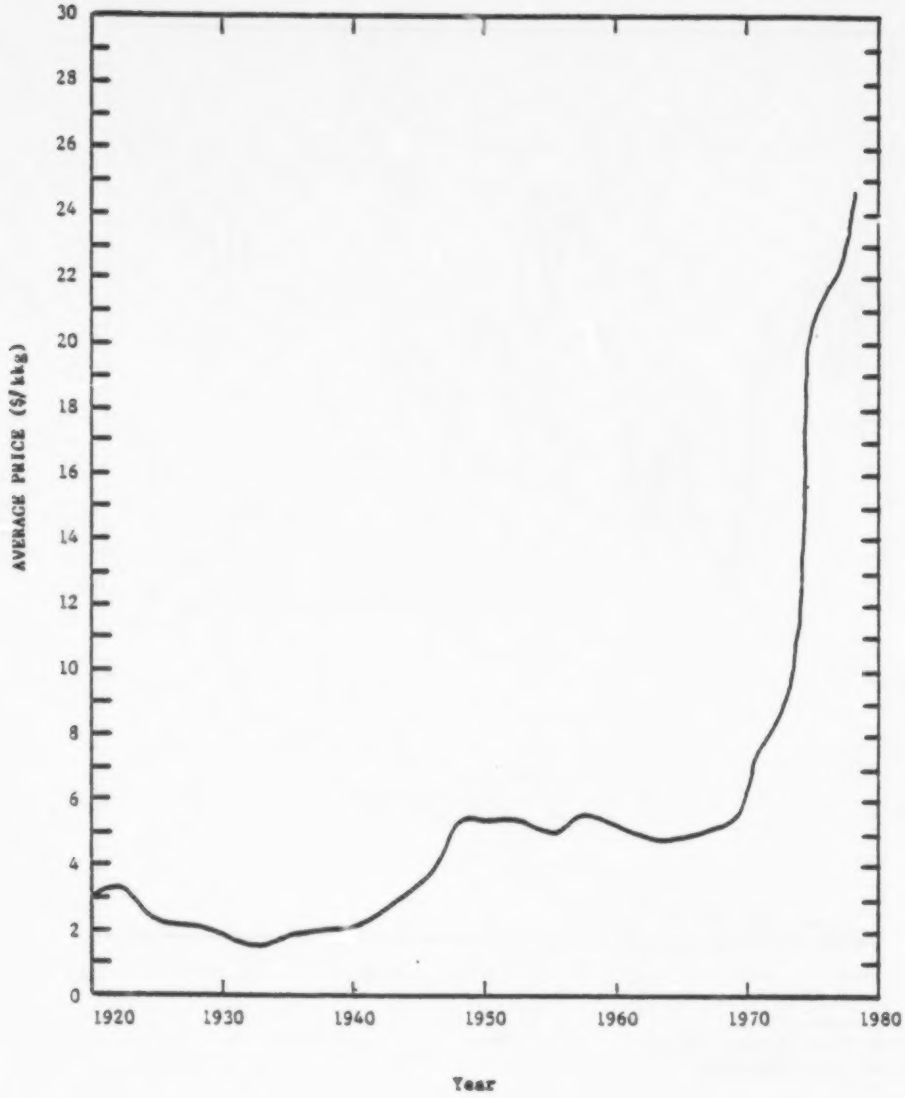


Figure IV-7
HISTORY OF COAL PRICES
(f.o.b. Mines)

Source: 1979 Keystone Coal Industry Data

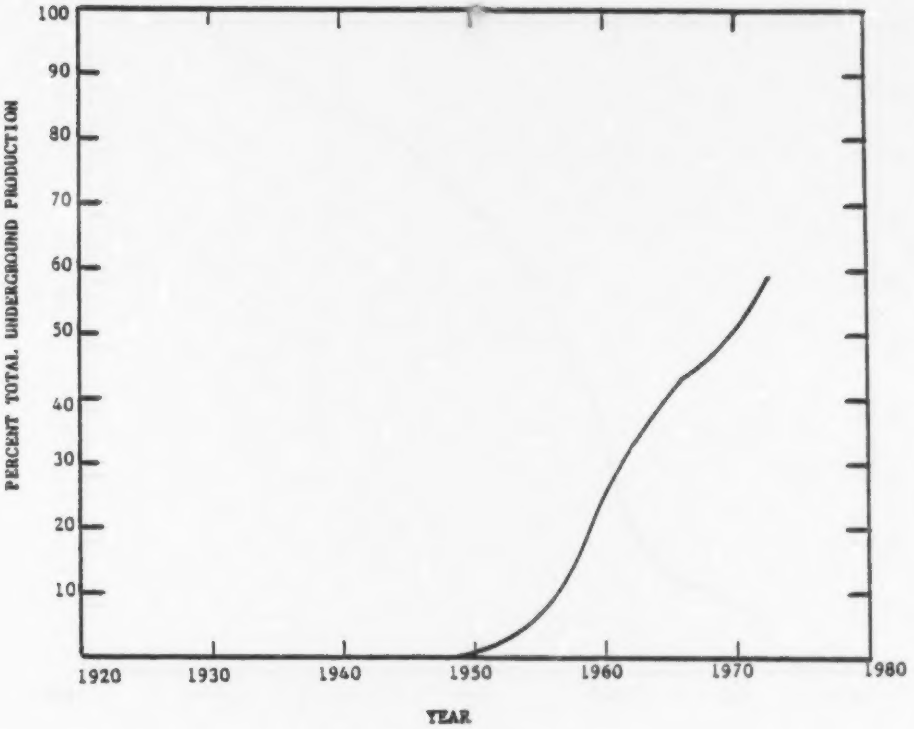


Figure IV-8

HISTORY OF UNDERGROUND COAL MINED BY CONTINUOUS MINING MACHINES

Source: 1979 Keystone Coal Industry Data

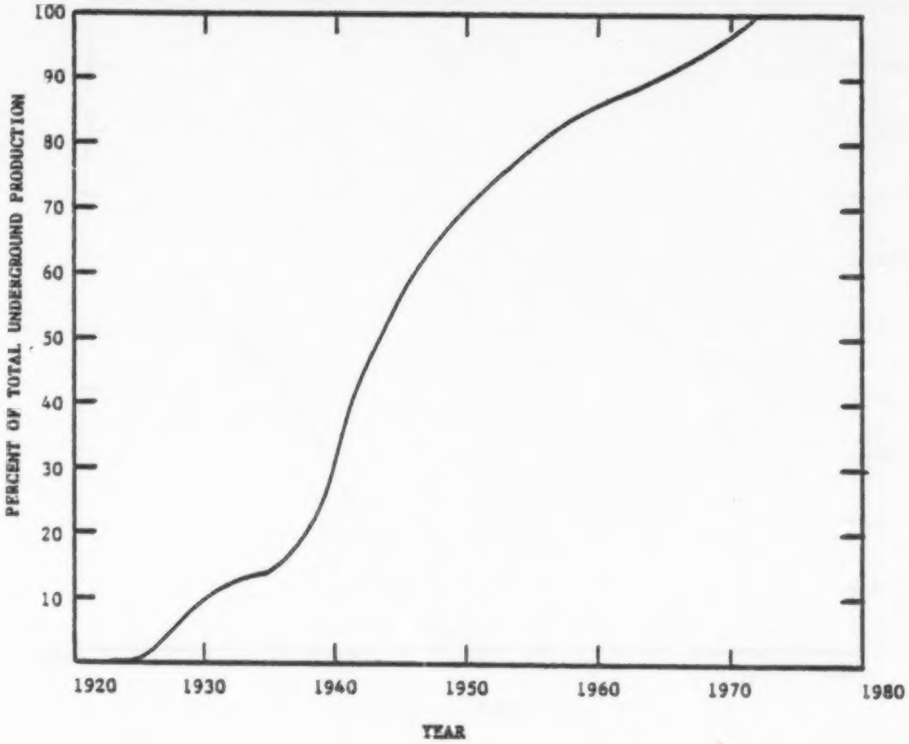


Figure IV-9
HISTORY OF UNDERGROUND COAL - MECHANICALLY LOADED

Source: 1979 Keystone Coal Industry Data

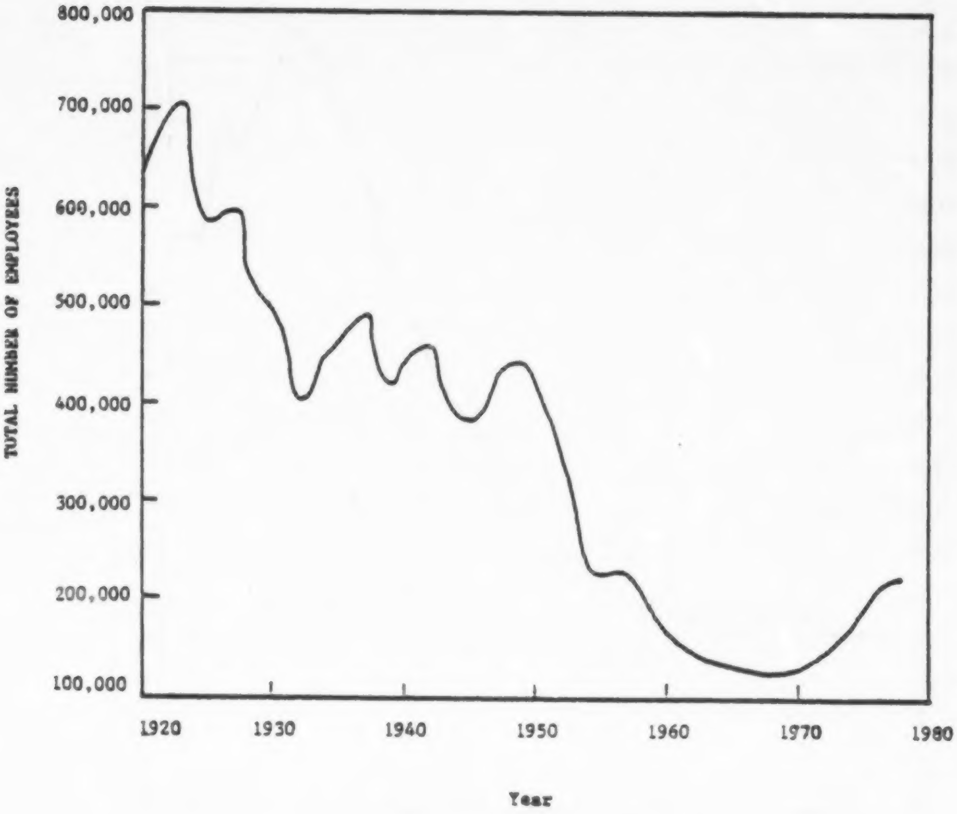


Figure IV-10
HISTORY OF NUMBER OF EMPLOYEES

Source: 1979 Keystone Coal Industry Data

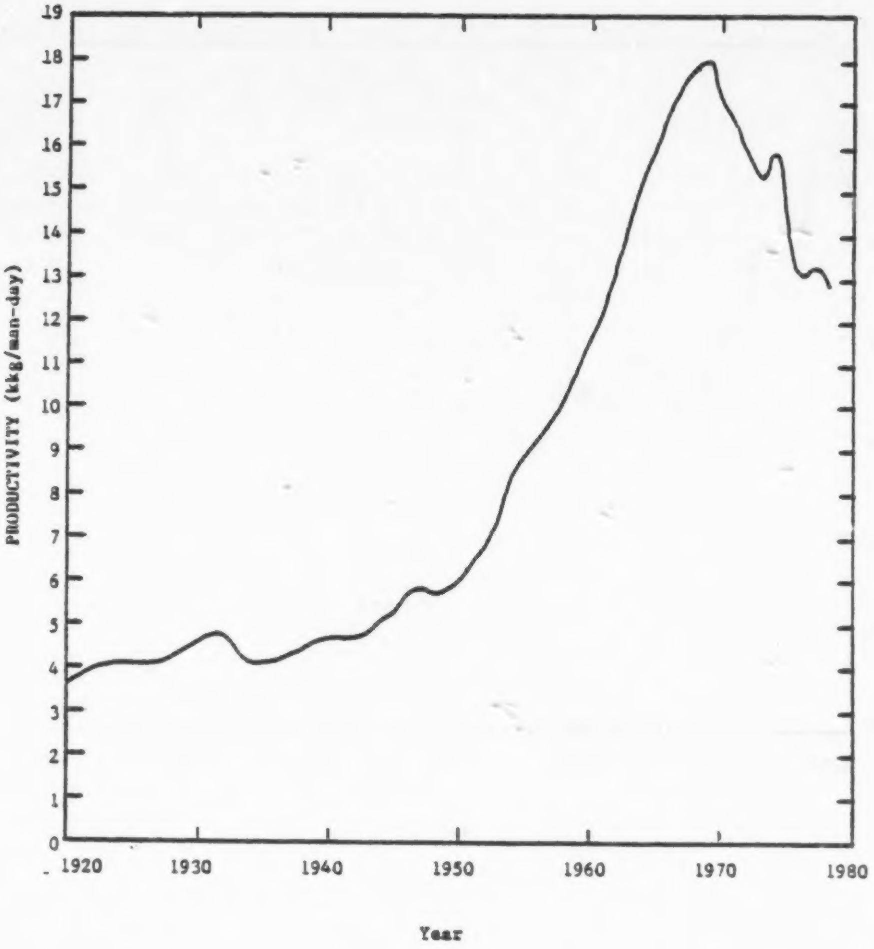


Figure IV-11
HISTORY OF PRODUCTIVITY RATES

Source: 1979 Keystone Coal Industry Data

The development of very high-voltage electrical transmission lines has provided another option for moving large quantities of energy to consumer areas from mine-based generating stations.

Figure IV-12 illustrates U.S. coal transportation by method of movement, 1976 and projected.

LOCATION AND PRODUCTION

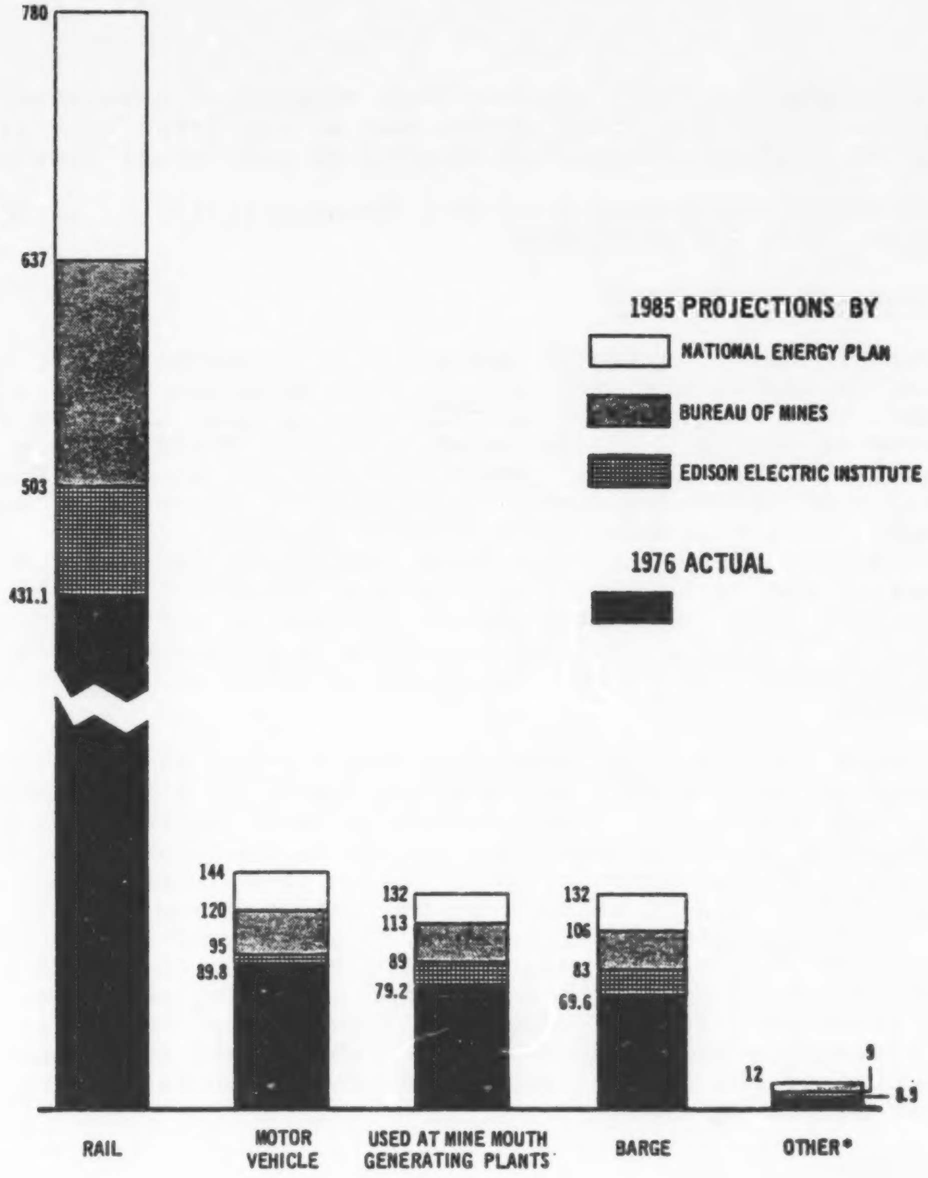
The coal industry currently operates in 26 states; mines are located in Appalachia, the Midwest, and Mountain and Pacific regions. The geographical distribution of coal mines by state and type of mining is illustrated in Figure IV-13. Table IV-8 lists the 1978 annual coal production for all states. The seven leading coal-producing states in 1978 were, in order of output, Kentucky, West Virginia, Pennsylvania, Wyoming, Illinois, Ohio, and Virginia. Production in these states accounted for 73 percent of the total 1978 U.S. output. Mines east of the Mississippi River accounted for 74 percent or 436 million metric tons of 1978 production, whereas mines west of the Mississippi River accounted for 26 percent or 157 million metric tons of 1978 production.

There were 6,075 active bituminous and lignite mines in the industry in 1978 controlled by approximately 3,800 companies (13). The majority of these mines are small operations, with individual production less than 90,700 metric tons (100,000 short tons) per year as shown in Table IV-9. These small operations accounted for over 80 percent of the active mines in 1975. However, they accounted for less than 20 percent of the bituminous and lignite coal production. In recent years, the trend has been toward larger mines and consolidation of mining companies. Table IV-10 gives 1978 annual production figures for the 15 biggest U.S. bituminous and lignite mines. Table IV-11 shows annual production of the 15 U.S. coal-producing companies having the highest output in 1978.

Anthracite

Figure IV-14 illustrates the location of the major anthracite coal fields, which are located in northeastern Pennsylvania, the only state where anthracite is currently mined.

In 1917, anthracite reached its peak production of approximately 90.3 million metric tons (99.6 million short tons). As the availability of cheaper, more convenient fuels increased, the demand for anthracite decreased to where production currently (1978) totals 4.6 million metric tons (5.0 million short tons). The recent exclusion of steam electric utility powerplants burning anthracite from the SO_2 New Source Performance Standards

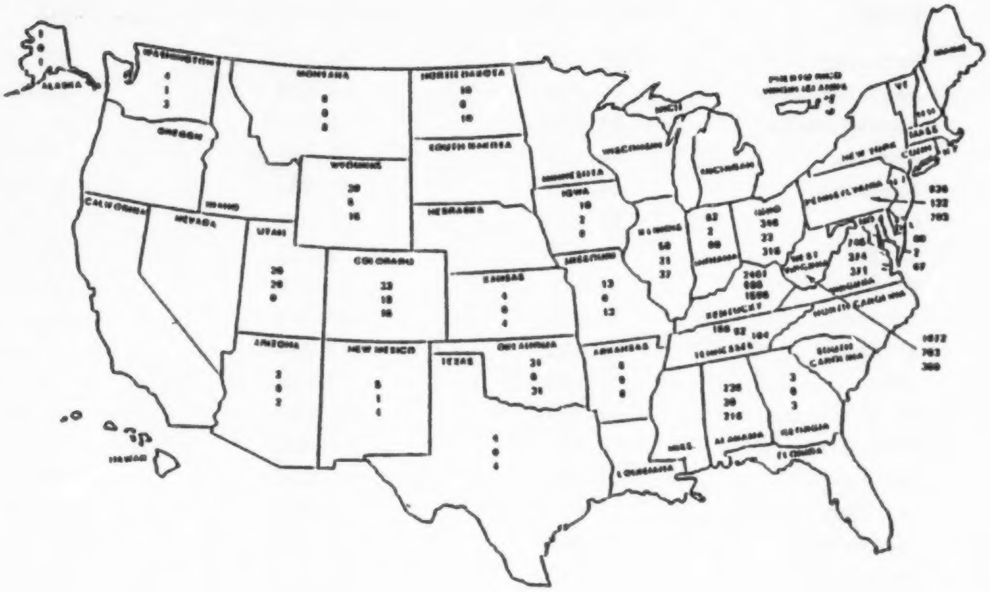


* Coal Slurry Pipeline or Used at Mine

Figure IV-12

U.S. COAL TRANSPORTATION BY METHOD OF MOVEMENT, 1976 AND PROJECTED (million tons)

Source: (15)


ALASKA
1
0
1
WASHINGTON
4
1
3
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
8
0
8
WYOMING
20
5
16
UTAH
26
26
0
COLORADO
33
18
16
ARIZONA
2
0
2
NEW MEXICO
5
1
4
HAWAII
NORTH DAKOTA
10
0
10
SOUTH DAKOTA
NEBRASKA
KANSAS
4
0
4
OKLAHOMA
31
0
31
TEXAS
4
0
4
MINNESOTA
IOWA
10
2
8
MISSOURI
13
0
13
ARKANSAS
8
0
8
LOUISIANA
WISCONSIN
MICH
ILLINOIS
58
21
37
MICHIGAN
INDIANA
62
2
60
OHIO
338
22
316
KENTUCKY
2401
805
1596
TENNESSEE
186
82
104
MISS.
ALABAMA
236
20
216
GEORGIA
3
0
3
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
705
374
331
WEST VIRGINIA
1072
703
369
MD
60
7
67
PENNSYLVANIA
836
132
703
NEW YORK
PUERTO RICO
VIRGIN ISLANDS
VT
N.H.
MASS
CONN
R.I.
MAINE

Sequential Listing Indicates:

Total Number of Mines
Total Number of Underground Mines
Total Number of Surface Mines (Includes Strip, Auger and Strip - Auger Mines)

Figure IV-13
GEOGRAPHICAL DISTRIBUTION OF COAL MINES

Source: (19)

Table IV-8

ESTIMATED 1978 COAL PRODUCTION BY STATE BITUMINOUS AND LIGNITE

Rank	State	Total $(kkg \div 10^6)^1$	Surface Methods $(kkg \div 10^6)^1$	Underground Methods $(kkg \div 10^6)^1$
1.	Kentucky	129.002	73.482	55.520
2.	West Virginia	74.389	16.329	58.060
3.	Pennsylvania	69.458[2]	38.795[2]	30.663
4.	Wyoming	44.452	43.998	0.454
5.	Illinois	44.421	21.484	22.937
6.	Ohio	37.921	26.463	11.458
7.	Virginia	32.477	9.525	22.952
8.	Montana	23.678	23.678	0.000
9.	Indiana	20.865	20.369	0.496
10.	Alabama	16.783	11.884	4.899
11.	Texas	15.966	15.966	0.000
12.	North Dakota	12.469	12.469	0.000
13.	Colorado	12.107	7.834	4.273
14.	New Mexico	11.793	11.060	0.733
15.	Arizona	10.614	10.614	0.000
16.	Tennessee	10.342	5.656	4.686
17.	Utah	9.253	0.000	9.253
18.	Missouri	5.141	5.141	0.000
19.	Oklahoma	4.536	4.536	0.000
20.	Washington	4.173	4.173	0.000
21.	Maryland	2.363	2.166	0.197
22.	Kansas	1.275	1.275	0.000
23.	Alaska	0.635	0.635	0.000
24.	Iowa	0.472	0.236	0.236
25.	Arkansas	0.463	0.450	0.013
26.	Georgia	0.159	0.159	0.000
	Total	592.207	368.377	226.830

(1) Multiply by 1.023 to obtain short (English) tons $\div 10^6$.

(2) Includes 259,000 kkg refuse.

Source: Based on preliminary estimates by State Mining Departments, Energy Information Administration and Keystone.

Table IV-9

BITUMINOUS AND LIGNITE COAL MINES, NUMBER AND PRODUCTION BY SIZE OF OUTPUT, 1975

Mine Size (i.e., Annual Production in Short Tons)	Number of Mines	Production (Short Tons ÷ 10^6)
500,000 tons or more	284	359.3
200,000 to 499,999 tons	327	101.6
100,000 to 199,999 tons	463	64.2
50,000 to 99,999 tons	800	56.0
10,000 to 49,999 tons	2,417	58.6
9,999 tons or less	1,877	8.7
TOTAL	6,168	648.4

Source: (19)

Table IV-10

THE 15 BIGGEST BITUMINOUS AND LIGNITE MINES IN 1978

Company	Name of Mine	State	Production (kkg ÷ 10^6)[1]
1. AMAX Coal Co.	Belle Ayr (S)	Wyoming	16.389
2. Western Energy Co.	Rosebud (S) (C)	Montana	9.594
3. Decker Coal Co.	Decker Nos. 1 & 2 (S)	Montana	8.231
4. Utah International Inc.	Navajo (S)	New Mexico	7.257
5. Peabody Coal Co.	Kayenta (S)	Arizona	6.143
6. Bridger Coal Co.	Jim Bridger (S)	Wyoming	4.695
7. Washington Irrigation & Dev. Co.	Centralia (S) (C)	Washington	4.264
8. Peabody Coal Co.	River King (D&S)	Illinois	4.171
9. Kemmerer Coal Co.	Elkol-Sorenson (S)	Wyoming	3.685
10. Sunoco Energy Devel. Co.	Cordero (S)	Wyoming	3.447
11. Consolidation Coal Co., Western Region	Glenharold (S)	North Dakota	3.344
12. Baukol-Noonan Inc.	Center (S)	North Dakota	3.084
13. Glenrock Coal Co.	Dave Johnston (S) (C)	Wyoming	3.018
14. Southwestern Illinois Coal Corp.	Captain (S)	Illinois	2.903
15. Arch Mineral Corp.	Medicine Bow (S)	Wyoming	2.812

(1) Multiply by 1.1023 to obtain short (English) tons x 10^6.

(S) Surface Mine

(D) Deep Mine

(C) Captive Mine (i.e., a mine whose basic purpose is to sell its coal back to its owner, for example, U.S. Steel operates mines that supply coking coal for its steel plants.)

Source: (13)

Table IV-11

TOP 15 COAL-PRODUCING GROUPS IN 1978

Group or Company	Production (kkg ÷ 10^6)[1]
Peabody Group	47.589
Consolidation Group	37.939
AMAX Group	27.023
Island Creek Group	12.328
Arch Mineral	11.717
NERCO Group (C)	10.355
Pittston Group	9.939
Western Energy (C)	9.594
U.S. Steel (C)	9.416
Peter Kiewit Group	9.293
Bethlehem Mines (C)	8.575
American Electric Power (C)	8.427
Pittsburg & Midway	7.131
Old Ben	7.023
North American Group	6.900
Total	223.249

(1) Multiply by 1.1023 to obtain short (English) tons ÷ 10^6.

(C) Captive Mine (for explanation, see table IV-13).

Source: (13).

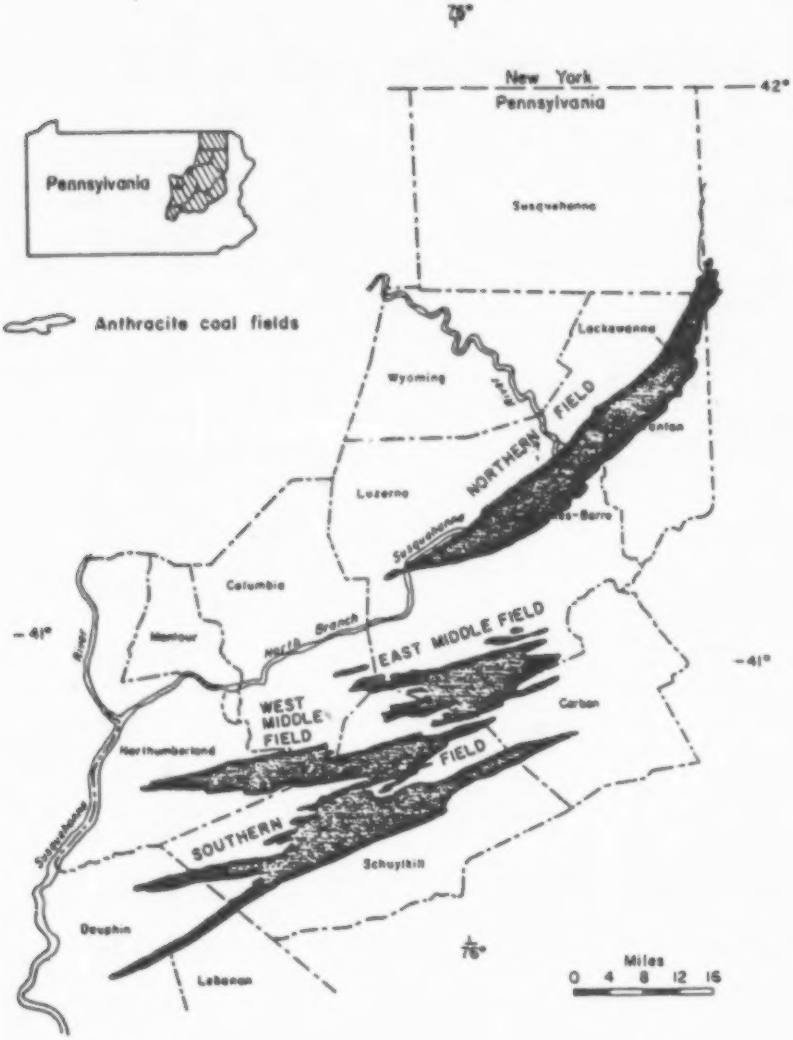

75°
New York
Pennsylvania
42°
Pennsylvania
Anthracite coal fields
Susquehanna
Lackawanna
Wyoming
River
NORTHERN FIELD
anton
Luzerne
es-Barre
Susquehanna
Columbia
Montour
North Branch
EAST MIDDLE FIELD
-41°
-41°
River
WEST MIDDLE FIELD
Carbon
Northumberland
SOUTHERN FIELD
Susquehanna
Schuylkill
Dauphin
Lebanon
76°
Miles
0 4 8 12 16

Figure IV-14

LOCATION OF THE MAJOR ANTHRACITE COAL FIELDS IN THE U.S.
NORTHEASTERN PENNSYLVANIA

Source: (11)

requiring scrubbing may help to make anthracite a more competitive fuel source in the future.

Anthracite is mined by several methods, including strip mining; underground mining; culm bank and silt pile removal (i.e., reworking the waste product from coal preparation plants); and dredging. About 59 percent of the anthracite produced in 1978 originated from strip mines, 29 percent from the reworking of refuse piles and culm banks, and about 12 percent from underground mines. The amount of anthracite produced from dredging was unknown in 1978, although it is estimated at less than one percent.

According to the Pennsylvania DER, there were approximately 280 anthracite mining operations in 1978, including 113 stripping operations, 104 deep mines, and 63 culm bank operations. These operations employed 2,297 personnel*. Available data indicate that 41 operators and 127 mines accounted for approximately 89 percent of the 1978 anthracite production (10).

The major consumer of Pennsylvania anthracite continues to be the residential and commercial space heating sector, which accounted for 34 percent of total consumption in 1975. The second largest consumer of Pennsylvania anthracite is the steam electric power generating industry which, in 1975, accounted for 24 percent of consumption. The third largest is the iron and steel industry, which consumes Pennsylvania anthracite primarily for coke-making, accounting for 20 percent of 1975 total consumption (16).

Pennsylvania anthracite is also used for electric power generation and space heating on United States' military bases in Europe. In 1973, a total of 631,000 metric tons (696,000 short tons) of anthracite was exported to military bases.

The remainder of Pennsylvania's anthracite is used for a number of other applications, including manufacture of soda ash, the carbon industry, coal electrodes, water filtration, bakery fuel, cement and lime manufacture, and at the mine itself to generate heat and power (16).

Anthracite's advantages in the coal market include its low sulfur content (about 0.6 percent sulfur), high Btu content (approximately 13,500 Btu's per pound), and proximity to the industrialized Northeast. Its disadvantages include complex geologic conditions resulting in high mining costs and widespread depletion of easily accessible and mineable coal veins. For further details on anthracite mining in the United States, refer to reference (11).

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*Another 1,175 personnel are employed at breakers and washeries (i.e., essentially coal preparation).

Bituminous, Subbituminous, and Lignite

Bituminous, subbituminous, and lignite deposits comprise over 99 percent of the nation's total coal reserves, as estimated by the U.S. Geological Survey (17). Deposits are widespread, occurring in several major coal-producing regions across the United States. Figure IV-15 illustrates the location of major bituminous, subbituminous, and lignite deposits in the United States. Bituminous coal has been a major source of energy in the United States since the early 1800's. Coal production has increased steadily in recent years because of continued improvement in strip mining machinery and in response to increased demands by the electric utility industry. Estimated 1979 production is 671 million metric tons. Surface production has increased significantly since the early 1960's, accounting for about 63 percent or 373 million metric tons of the total 1978 production of 593 million metric tons, whereas underground production has remained relatively stable for the last 15 years, totaling 220 million metric tons in 1978, (see Figure IV-5). The number of production workers mining bituminous coal and lignite has increased steadily from a 1969 level of 124,000 to a 1978 level of 221,000 (see Figure IV-10). Only 75,000 personnel were employed at surface mines in 1978, even though surface operations accounted for 63 percent of 1978 total production. By comparison, 146,000 personnel were employed at underground operations that produced only 37 percent of 1978 total production. The more labor-intensive underground operations (but lower total production) can be explained by the lower productivity rates when compared to surface mines; i.e., 7.48 metric tons per man-day (8.25 short tons per man-day) for underground mines versus 12.94 metric tons per man-day (14.26 short tons per man-day) for surface mines.

FUTURE

Production and Expansion

A goal of 1.1 billion metric tons (1.2 billion short tons) of coal production has been set for 1985 by the Carter Administration (14). However, the National Coal Association (NCA) estimates that this goal will not be achieved until 1990. U.S. recoverable coal reserves by both surface and underground methods currently total 191 billion metric tons (210 billion short tons) of bituminous, subbituminous and lignite coal (14). Table IV-12 lists the 15 American companies that control the most coal reserves.

NCA's latest five-year forecast predicts domestic coal production will "most likely" be 805 million metric tons (887 million short tons) in 1983. Most of the increase in production will come from new, high-production western surface mines or expansions of existing western surface mines. NCA forecasts that 1983 coal

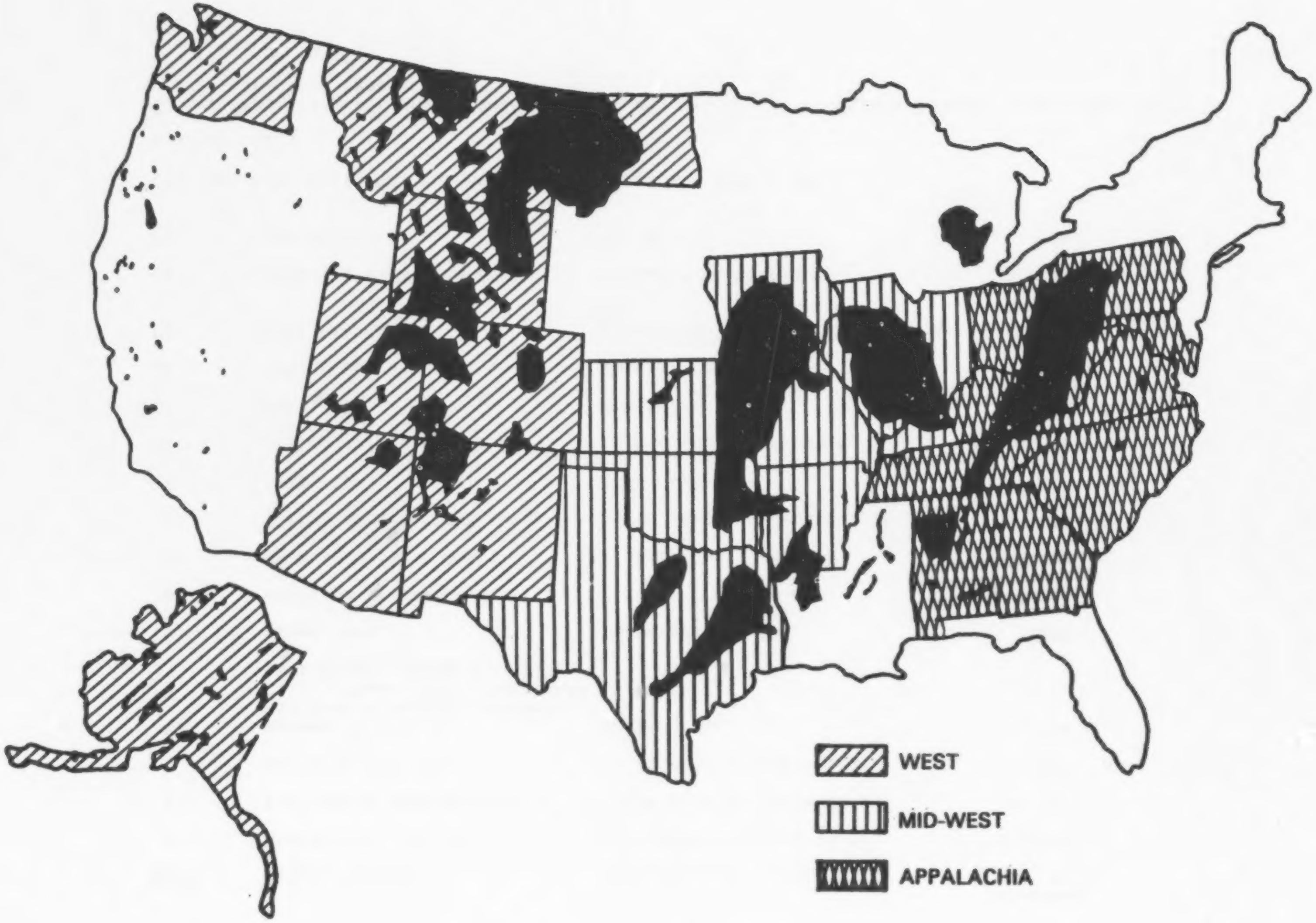

WEST
MID-WEST
APPALACHIA

Figure IV-15
MAJOR BITUMINOUS, SUBBITUMINOUS AND LIGNITE COAL DEPOSITS IN THE UNITED STATES

Source: (18)

Table IV-12

COAL RESERVES OF THE TOP 15 U.S COMPANIES

Rank	Parent Company	Coal Operating Company	Reserves (kkg 10^9)[1]
1.	Continental Oil Co.	Consolidation Coal Co.*	12.428
2.	Burlington Northern Inc.	Burlington Northern Inc.	10.342
3.	Union Pacific Co.	Rocky Mountain Energy Co.	9.072
4.	Newmont Mining Co.; Williams Companies; Bechtel Corp.; Fluor Corp.; Equitable Life Assur. Society of U.S.	Peabody Coal Co.	8.074
5.	Exxon Corp.	Monterey Coal Co.	7.620
6.	Phillips Petroleum	Phillips Petroleum	7.257
7.	El Paso Natural Gas	El Paso Coal Co.	4.717
8.	North American Coal Corp.	North American Coal Corp.*	4.627
9.	AMAX, INC.	AMAX Coal Co.	4.577
10.	Occidental Petroleum Co	Island Creek Coal Co.*	4.019
11.	Mobil Corp.	Mobil Corp.	3.175
12.	United States Steel Corp.	United States Steel Corp.	2.722
13.	Gulf Oil Co.	Pittsburgh & Midway Coal Mining Co.	2.359
14.	Atlantic Richfield Co.	Atlantic Richfield Co.	1.996
15.	Sun Oil Co.	Sun Oil Co.	1.996

(1) Multiply by 1.1023 to obtain short (English) tons - 10^9.

Source: (13)

*Note: These figures are estimated totals and do not differentiate between recoverable or in-place reserves.

output west of the Mississippi River will increase to 277 million metric tons (305 million short tons), an increase of 42 percent over the 1979 level. Coal production east of the Mississippi River, however, will rise only 11 percent to 528 million metric tons (582 million short tons) (14). Wyoming may soon become the nation's top coal-producing state, due to the expansion plans for the Powder River Basin area in Campbell County. Table IV-13 shows demonstrated U.S. coal reserves by region and coal rank.

Exports/Imports

According to NCA estimates, exports of coal will rise by only nine percent in 1983 over 1979 levels, whereas imports of coal and coke are expected to increase 91 percent by 1983. Exports are not expected to increase significantly, mainly because U.S. coal is slowly losing its ability to compete in world markets due to higher extraction and transportation costs (14). However, according to DOE projections, bituminous coal exports will increase over 21 percent by 1983 and over 37 percent by 1990, to 81 million tons (8). The principal receiving nations are Canada and Japan.

Utilization

A very large percentage of new coal production will be utilized for steam electric generation. According to one estimate (see Figure IV-3) coal use by market sector in 1985 will amount to 79 percent for electric utilities, 11 percent for general industry and retail, and 10 percent for coke plants.

As additional emphasis is placed on synthetic fuels, coal gasification and coal liquefaction technology will become increasingly more important. Figure IV-16 portrays areas of high potential for gasification development.

Productivity and Prices

Figure IV-11 shows the history of productivity for bituminous, subbituminous, and lignite mines. Within the last decade, productivity has gradually declined. For example, Figure IV-11 shows that in 1969, overall productivity reached a high of 18.05 metric tons per man-day (19.90 short tons per man-day), but by 1978 productivity had fallen off to 12.94 metric tons per man-day (14.26 short tons per man-day), a decline of 28 percent. Productivity for surface mines is significantly higher than for underground mines; e.g., 22.68 metric tons per man-day (25.00 short tons per man-day) versus 7.48 metric tons per man-day (8.25 short tons per man-day).

Table IV-7 and Figure IV-7 show the history of average f.o.b. coal prices in the United States. This price has been steadily

Table IV-13
DEMONSTRATED* U.S. COAL RESERVES BY REGION AND COAL RANK
(billion tons)

		COAL RANK				TOTALS	
		Bituminous	Sub-Bituminous	Anthracite	Lignite	Sub-Total	Grand Total
APPALACHIA	Surface	18.794	-	.143	1.083	20.020	111.622
	Deep	84.498	-	7.104	-	91.602	
MID-WEST	Surface	26.108	-	.008	3.208	29.324	104.502
	Deep	75.089	-	.089	-	75.178	
WEST	Surface	1.951	60.686	-	28.900	91.537	221.558
	Deep	22.271	107.722	.028	-	130.021	
TOTAL	Surface	46.853	60.686	.151	33.191	140.881	
	Deep	181.858	107.722	7.221	-	296.801	
	Total	228.711	168.408	7.372	33.191		437.682

Demonstrated Reserves Potentially Mineable (as of January 1, 1976) 437.682

* Measured and indicated deposits, half of which may be considered "recoverable" and are so designated.

Source: U.S. Bureau of Mines

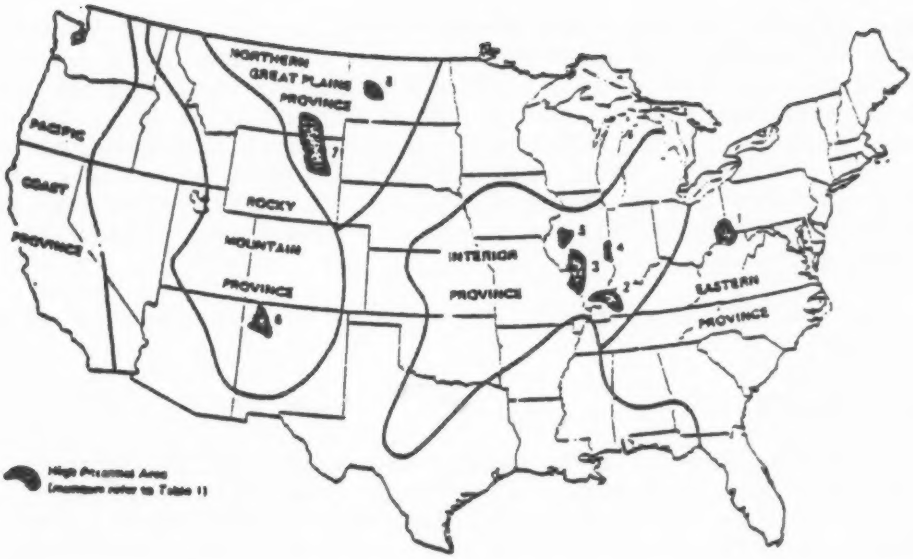

NORTHERN
GREAT PLAINS
PROVINCE
PACIFIC
COAST
PROVINCE
ROCKY
MOUNTAIN
PROVINCE
INTERIOR
PROVINCE
EASTERN
PROVINCE
1
2
3
4
5
6
7
8
High Potential Area
(numbers refer to Table 1)

Figure IV-16

AREAS OF HIGH POTENTIAL FOR GASIFICATION DEVELOPMENT

Reprinted, with permission, from "Coal in America," by Richard A. Schmidt. Copyright 1979, McGraw-Hill, Inc.

Source: U.S. Bureau of Mines

increasing since 1965. In 1965, the average f.o.b. mine price was $4.89 per metric ton, whereas in 1978 it had reached $24.69 per metric ton, a 500 percent increase in 13 years. Part of this increase is due to the equivalent energy cost of imported oil as is indicated by the large jump in the 1974 average coal price versus 1973 (e.g., $17.36 per ton versus $9.28 per ton, an increase of 87 percent), which occurred primarily as a result of the oil embargo and the large increase in the cost of OPEC crude.

MINING METHODS

Surface Mining

Surface mining is employed where the coal is close enough to the surface to enable the overburden (the soil and rock above the coal) to be removed economically and later replaced or regraded. Types of equipment used to remove overburden at U.S. mines include draglines; bucket wheel excavators; old generation stripping shovels; cable shovels and trucks; hydraulic shovels and trucks; front-end loaders and trucks; scraper-dozer units; and dozers assisting either front-end loaders, hydraulic shovels, or cable shovels.

There are two general types of surface mines--contour mines and area mines.

Contour Mining

Contour mining prevails in mountainous and hilly terrain such as Appalachia. For instance, if a coal seam is visualized as lying level at an elevation of 1,000 feet above sea level, and the land surface elevation varies from 600 to 1,400 feet above sea level, a contour stripping situation exists. Mining commences where the coal and surface elevations are the same, commonly called the cropline, and proceeds around the side of the hill on the cropline elevation.

The earth overlying the coal (overburden) may be removed by shovel, dragline, scraper, or bulldozer, depending on the depth and type of overburden encountered. The overburden is removed and the coal is loaded into trucks and removed from the pit. A second cut or pit can then be excavated by placing the overburden from it back into the first cut or pit.

Succeeding cuts, if any, would follow in the same sequence, with the amount of overburden increasing on each succeeding cut until the economic limit of the operation, or the maximum depth limit of the overburden machine (i.e., dragline or stripping shovel), is reached.

In the preceding description, only a single-level seam operation has been considered. There are many situations where several seams of coal may exist and they may pitch at various angless from the horizontal, as is fairly common in West Virginia and Pennsylvania. Although the mining of multiple or pitching seams is more complicated, the principle of contour stripping remains the same--finding where the surface and coal elevations are the same and following this contour until the economic limit is reached. Several types of contour mining practices exist. The primary distinction in most of these procedures is the method of spoil disposal.

Spoil Deposited Over Side of Hill. This practice has been virtually eliminated by the Federal Surface Mining Control and Reclamation Act of 1977 (SMCRA), which prohibits the placing of materials on the downslope in steep mining situations (i.e., Appalachian area, on slopes 20° or greater). In past practices, this was the easiest way to get rid of overburden from the first cut in a hillside, by casting it over the side onto the downslope. Overburden from the second cut was then placed into the mined-out first cut and so on until the economic limit of the operation was reached. The highwall left at the end of mining often remained essentially unreclaimed, except the coal seam was generally covered up; methods sometimes varied according to state law. SMCRA requires that highwalls be reclaimed, thereby eliminating this past practice. Also, the practice of spoiling on the downslope has been replaced by techniques whereby spoil from the first cut or pit(s) is placed in hollow fills, or is stockpiled, hauled, conveyed, or pushed into a mined-out pit (or any combination of these techniques). Because of the significantly increased costs of producing coal by contour mining (partially as a result of eliminating past practices), many such operations have been eliminated or replaced by mountain-top or finger-ridge mining techniques. Figure IV-17 illustrates the contour mining method when spoil is deposited over the side of the hill.

Spoil Deposited in Hollow Fills. This method employs placement of spoil from initial cuts into approved hollow fills. Hollow fill design criteria varies from state to state. Figure IV-18 portrays a West Virginia hollow fill.

Haulback Mining. Truck haulback has become a successful technique for surface mining coal throughout the Appalachian regions. The haulback method, as the name implies, involves haulage of spoil laterally back along the bench, where it is placed on the pit floor. However, spoil from initial pits is either stockpiled or placed in hollow fills. This method offers many advantages environmentally and helps coal operators to comply with two significant provisions of SMCRA: (1) the requirement that

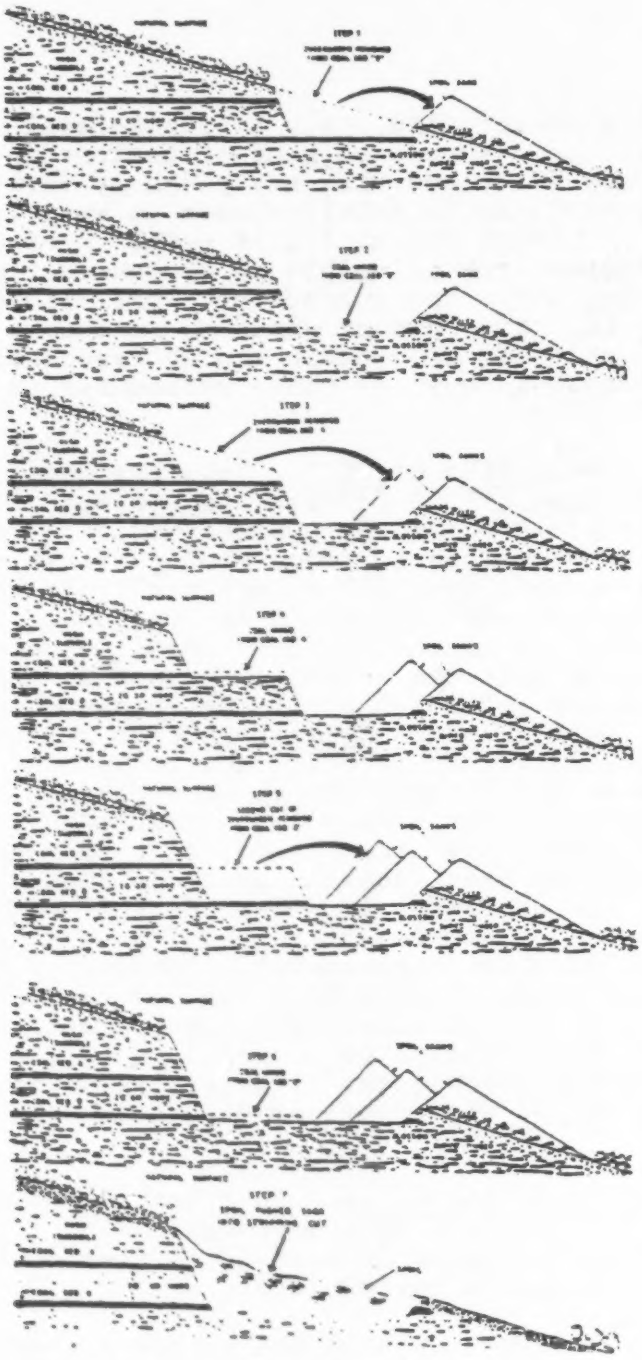
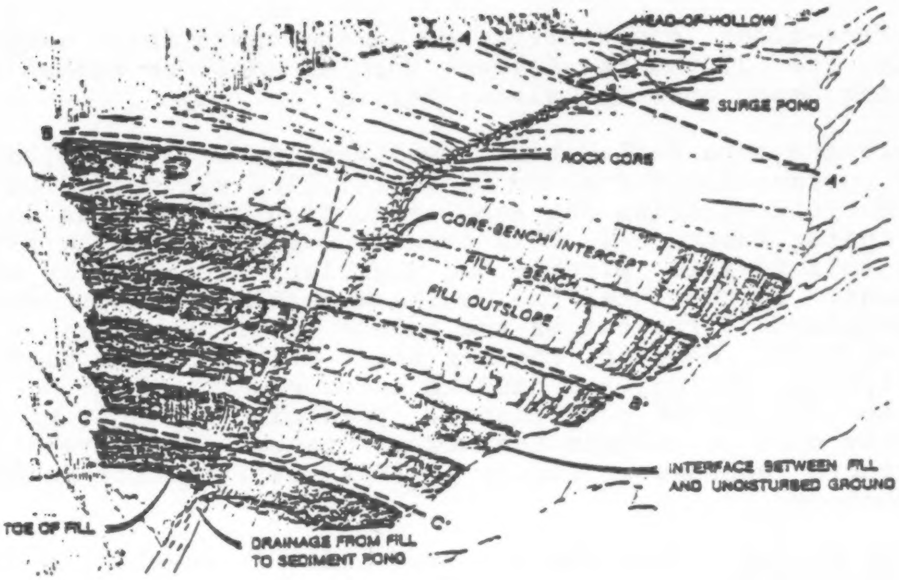


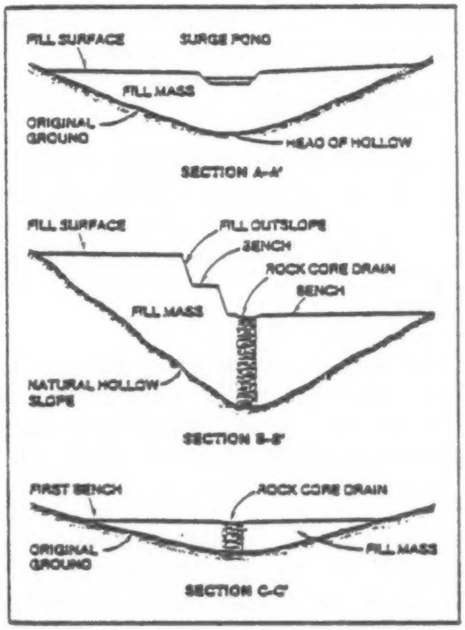
Figure IV-17

CONTOUR MINING (STRIPPING)
(Spoil Deposited Over Side of Hill)

Reprinted, with permission, from "Coal in America," by Richard A. Schmidt. Copyright 1979, McGraw-Hill, Inc.

Source: U.S. Bureau of Mines.


HEAD-OF-HOLLOW
A
SURGE POND
A'
B
ROCK CORE
CORE-BENCH INTERCEPT
FILL BENCH
FILL OUTSLOPE
B'
C
INTERFACE BETWEEN FILL AND UNDISTURBED GROUND
TOE OF FILL
DRAINAGE FROM FILL TO SEDIMENT POND
C'


FILL SURFACE
SURGE POND
FILL MASS
ORIGINAL GROUND
HEAD OF HOLLOW
SECTION A-A'
FILL SURFACE
FILL OUTSLOPE
BENCH
ROCK CORE DRAIN
BENCH
FILL MASS
NATURAL HOLLOW SLOPE
SECTION B-B'
FIRST BENCH
ROCK CORE DRAIN
ORIGINAL GROUND
FILL MASS
SECTION C-C'

West Virginia's present head-of-hollow criteria (far left) requires that all water enter a surge pond and rock core to drain down through center of fill (left). Example of this type of construction is the fill (above) built at Buffalo Mining Co.'s Gopher mine.

Figure IV-18

WEST VIRGINIA HOLLOW FILL

Reprinted, with permission, from "Coal Age Operating Handbook of Coal Surface Mining and Reclamation," Volume 2. Copyright 1978, McGraw-Hill, Inc.

surface-mined land be returned to the approximate original contour, and (2) the requirement that no spoil be pushed over the mining bench onto the slopes below.

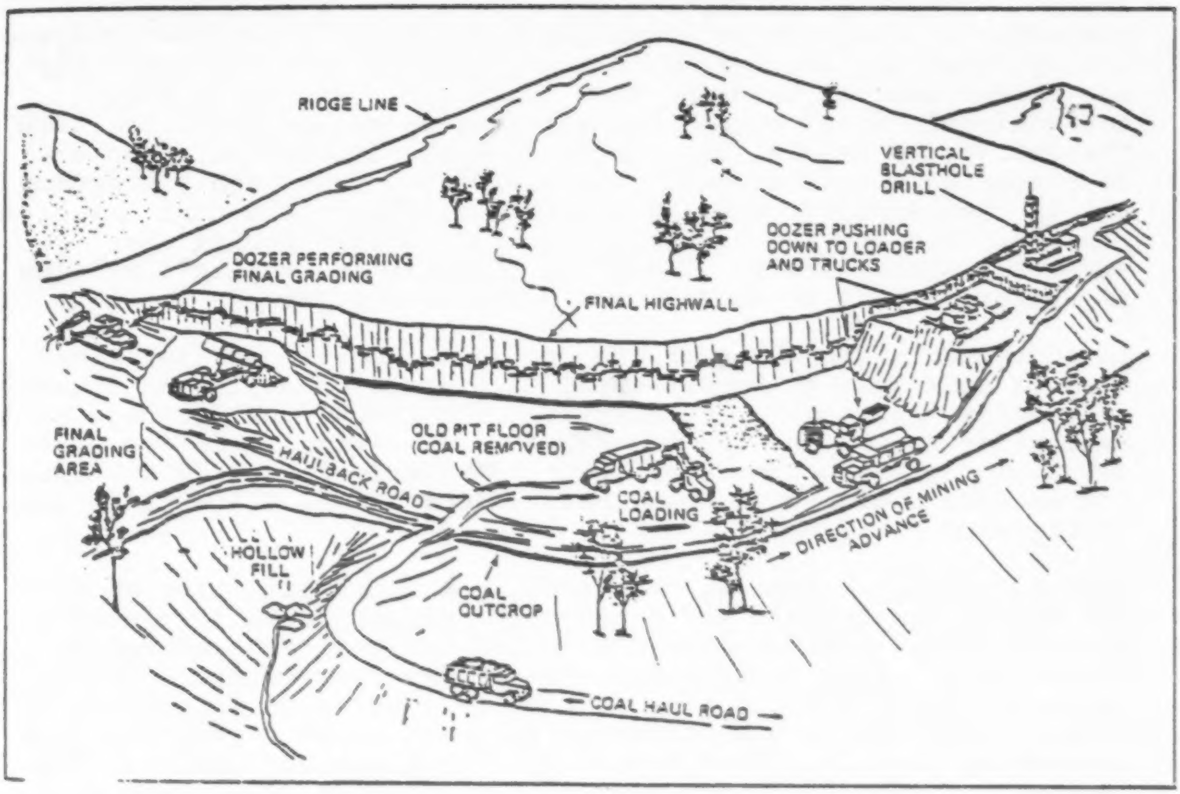
There are some reclamation advantages as well. Haulback permits the surface-mined area to be back-filled and seeded on a continuous cycle, sharing the same production schedule as the coal or stripping functions. This permits revegetating the slopes while the soil is still pliable and auxiliary equipment is still around. Furthermore, the haulback method also cuts down by approximately two-thirds the amount of disturbed lands at any given time. However, the logistics of timing the blasting, stripping, mining, and hauling sequences in the truck haulback method can become complicated. This mining technique is now widely used in eastern Kentucky, southern West Virginia, and northern Tennessee. Figure IV-19 illustrates the haulback mining technique.

Auger Mining. When the economic limit is reached in normal surface mining operations, the coal seam remains exposed at the bottom of the final highwall. This coal can be partially recovered by one of three methods: conventional underground mining, punch mining (a series of entries into a seam by a continuous miner), or auger mining (spiral boring for additional recovery of a coal seam exposed in a highwall).

Auger mining is usually applied to contour operations but can also be utilized in area type mining. Some mines, especially in Kentucky, use the auger method only. The coal seams are augered from specially prepared narrow benches, some only about 20 feet wide, and from a low highwall that is scarcely more than the thickness of the coal seam.

Records show that coal recovery by augering is quite low, usually less than 35 percent, and penetration generally is only about 150 feet. Unless properly planned, such mining can shut off large blocks of future deep coal by making the reserve very expensive to reach.

Low as the coal recovery is from auger mining, there are conditions where it is warranted as it is low-cost production and frequently makes it possible to mine coal reserves that are thin, dirty, isolated, and not economically recoverable by any other means. Auger mining accounts for about 2.5 percent of total U.S. coal production.


RIDGE LINE
VERTICAL BLASTHOLE DRILL
DOZER PUSHING DOWN TO LOADER AND TRUCKS
DOZER PERFORMING FINAL GRADING
FINAL HIGHWALL
FINAL GRADING AREA
OLD PIT FLOOR (COAL REMOVED)
HAULBACK ROAD
COAL LOADING
DIRECTION OF MINING ADVANCE
HOLLOW FILL
COAL OUTCROP
COAL HAUL ROAD

(Single-seam haulback operation in Appalachia involves three integrated phases of overburden removal, coal loading, and reclamation.)

Figure IV-19

HAULBACK MINING

Reprinted, with permission, from "Coal Age Operating Handbook of Coal Surface Mining and Reclamation," Volume 2. Copyright 1978, McGraw-Hill, Inc.

Area Mining

Strip Mining. In some regions of the United States, especially in the West and Midwest, many of the economically significant coal seams lie in a relatively level plane beneath a flat to gently rolling surface terrain. Consequently, the depth of the coal below the surface will remain fairly constant over extensive areas. This type of deposit can ordinarily be developed by conventional dragline or shovel methods using "area type" surface mining; that is, excavation of a sequence of parallel pits which may extend several thousand feet in length. Mining by the conventional "area" method normally begins at the cropline where the overburden is shallow. Spoil from the initial cut (box cut) is placed on virgin ground. The overburden from each succeeding pit is then spoiled into the previous pit where the coal has been removed. Reclamation operations follow closely behind the advancing mining front. The final highwall and entire mine area is reclaimed back to approximate original contour.

In addition to draglines or conventional shovels, stripping can also be performed by bucket-wheel excavators, shovels and trucks, endloaders and trucks, or scrapers. The trucks and scrapers haul overburden around the end of the pit, depositing it in the mined-out strip-cuts or other spoil storage sites. Figure IV-20 illustrates area mining with draglines. Figure IV-21 illustrates area mining with a stripping shovel.

Open-Pit Mining. Some western area type mines utilizing shovels and trucks, endloaders and trucks, or scrapers develop open-pit mine configurations whereby overburden and coal are removed in blocks rather than strip-cuts. Overburden from initial pits is normally placed off the area to be mined, often in depression areas, sometimes on previously mined areas, then overburden from succeeding pits is placed back into pits where the coal has been removed. Figure IV-22 portrays open-pit mining of a thick seam.

Other New Surface Mining Methods

Mountaintop Mining. In recent years, several mining techniques have been developed which minimize the adverse effects of mining on steep slopes. Because of new strip mine laws and reclamation requirements, these techniques have often replaced or eliminated the practice of contour mining. The new methods include mountaintop (or hilltop) mining and finger-ridge mining. Figure IV-23 depicts the cross-ridge concept of mountaintop mining.

The mountaintop mining method involves removal of the entire hilltop or mountaintop above a coal seam or multiple coal seams. Most of the overburden is usually placed in hollow fills, while some overburden is retained for final reclamation of the

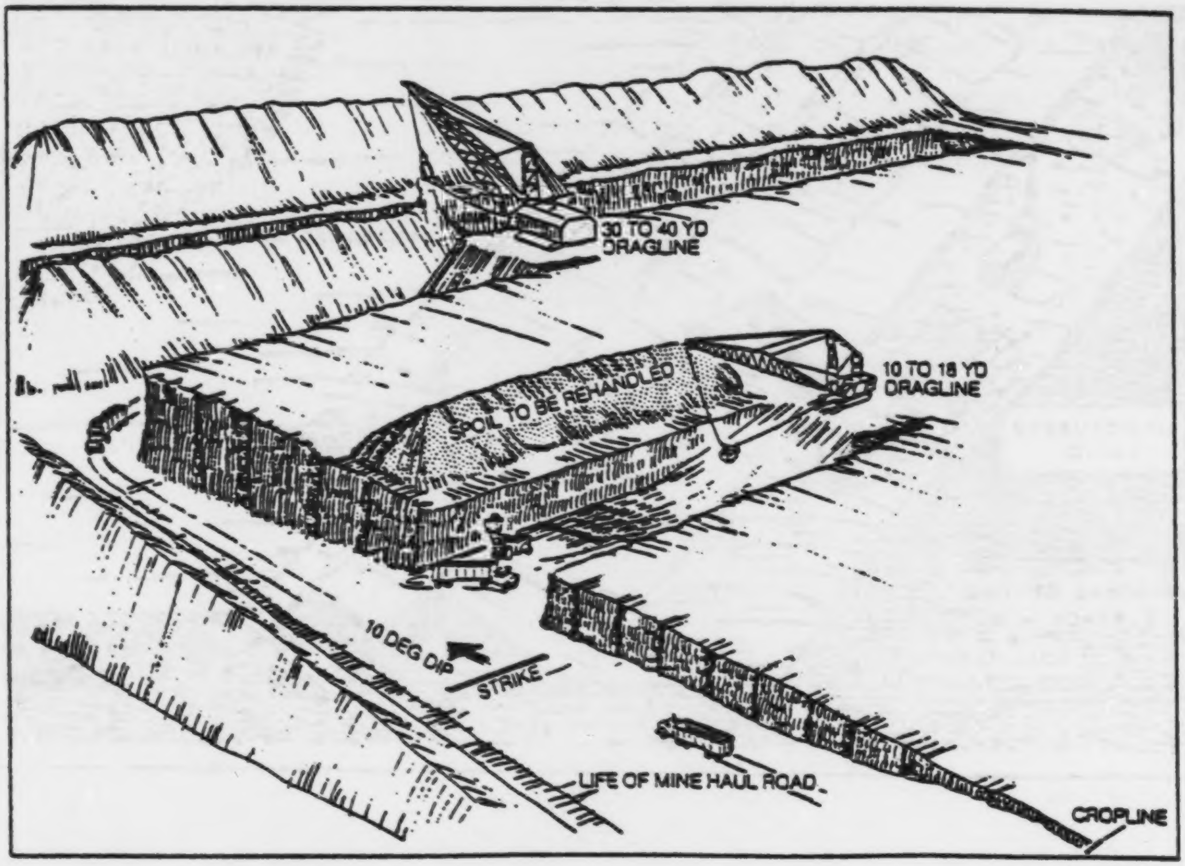

30 TO 40 YD
DRAGLINE
10 TO 18 YD
DRAGLINE
SPOIL TO BE REHANDLED
10 DEG DIP
STRIKE
LIFE OF MINE HAUL ROAD
CROPLINE

Figure IV-20

AREA MINING WITH DRAGLINES

Reprinted, with permission, from "Coal Age Operating Handbook of Coal Surface Mining and Reclamation," Volume 2. Copyright 1978, McGraw-Hill, Inc.

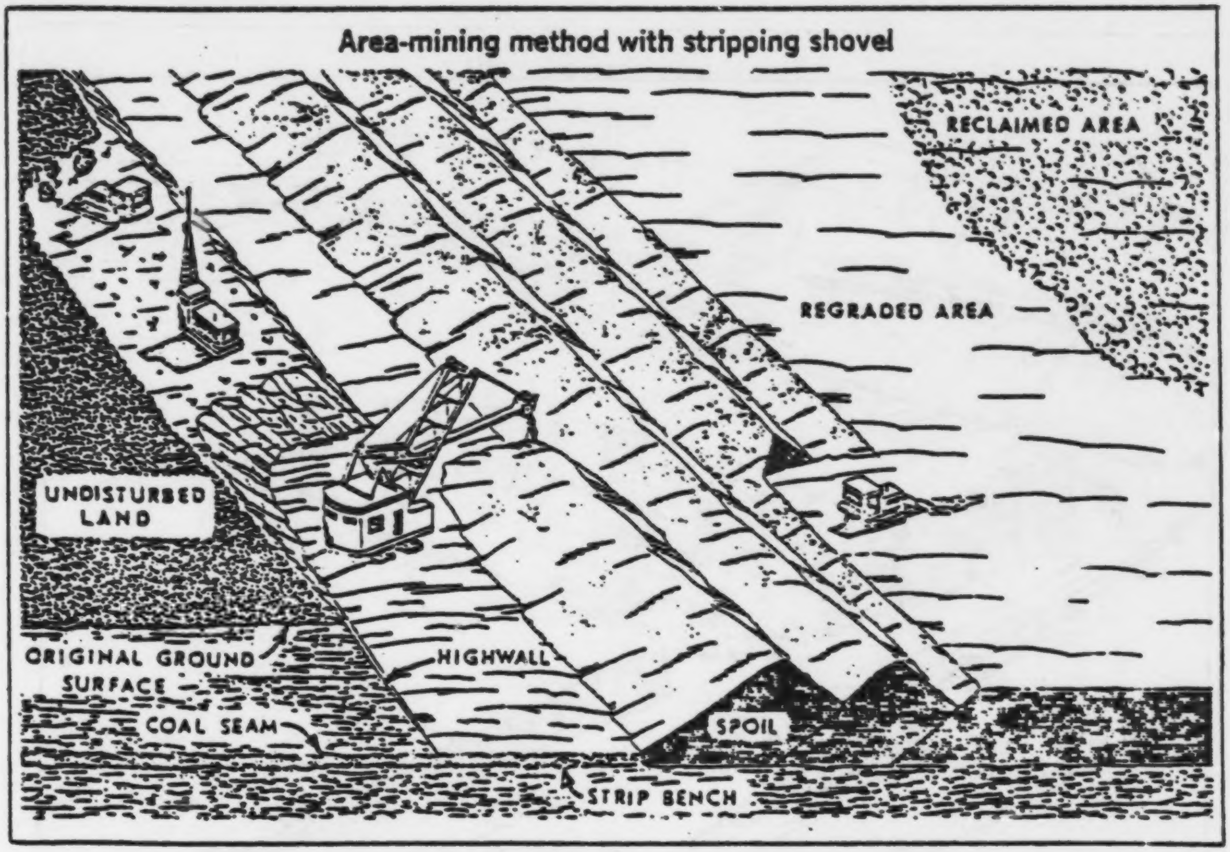

Area-mining method with stripping shovel
RECLAIMED AREA
REGRADED AREA
UNDISTURBED LAND
ORIGINAL GROUND SURFACE
HIGHWALL
COAL SEAM
SPOIL
STRIP BENCH

Figure IV-21

AREA MINING WITH STRIPPING SHOVEL

Reprinted, with permission, from "Coal Age Operating Handbook of Coal Surface Mining and Reclamation," Volume 2. Copyright 1978, McGraw-Hill, Inc.

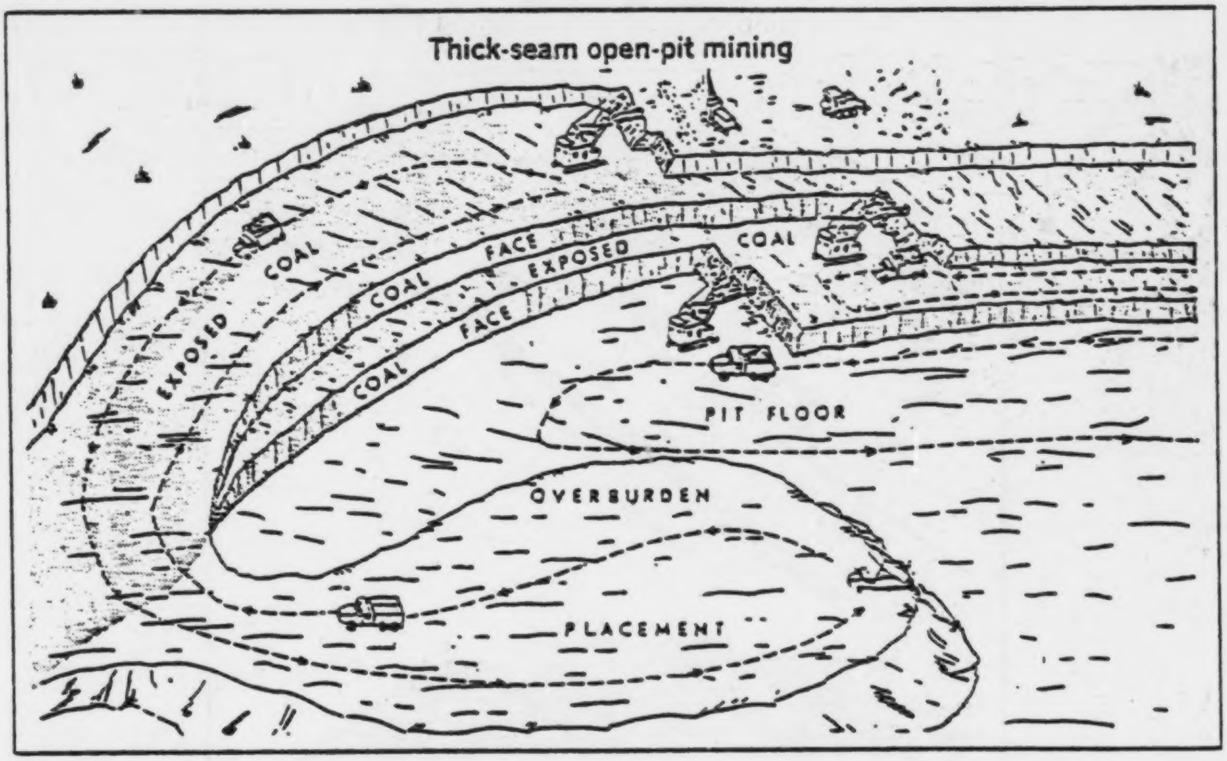

Thick-seam open-pit mining
EXPOSED COAL
COAL FACE
EXPOSED COAL
COAL FACE
COAL
PIT FLOOR
OVERBURDEN
PLACEMENT

Figure IV-22

AREA MINING (OPEN-PIT MINING) OF A THICK SEAM

Reprinted, with permission, from "Coal Age Magazine," February, 1980, Volume 85 - Number 2. McGraw-Hill, Inc.

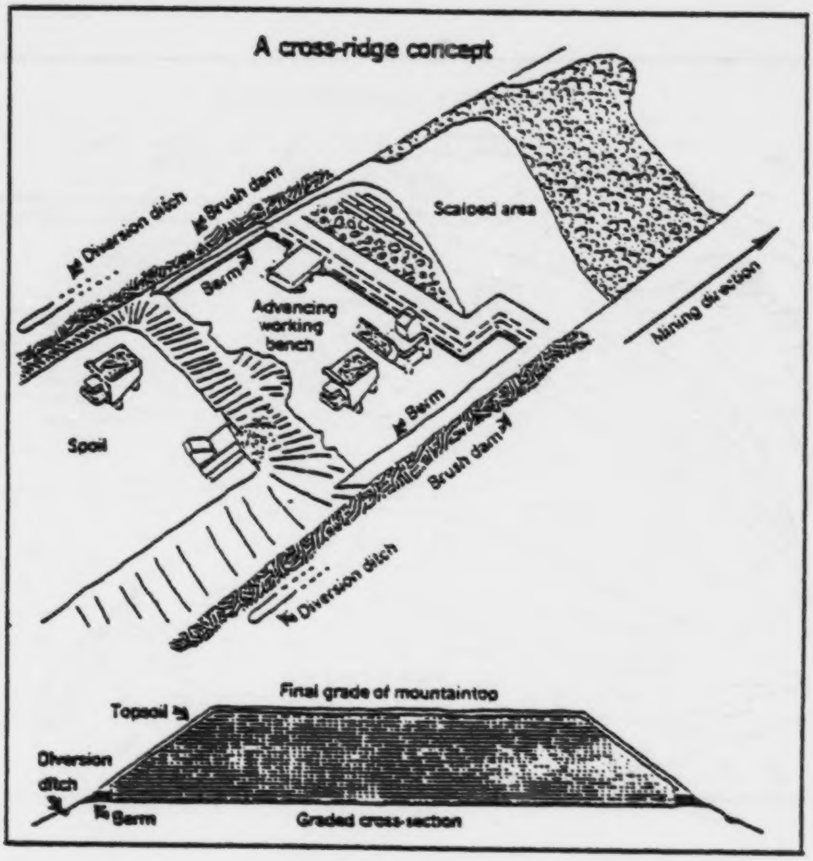

A cross-ridge concept
Diversion ditch
Brush dam
Scaloed area
Berm
Advancing working bench
Mining direction
Spoil
Berm
Brush dam
Diversion ditch
Final grade of mountaintop
Topsoil
Diversion ditch
Berm
Graded cross-section

Figure IV- 23

AREA MINING
(CROSS-RIDGE MOUNTAINTOP METHOD)

Reprinted, with permission, from "Coal Age Operating Handbook of Coal Surface Mining and Reclamation," Volume 2. Copyright 1978, McGraw-Hill, Inc.

"tabletop" landscape left upon termination of mining. A new mountaintop technique, called cross-ridge mining, mines across the ridges between the coal outcrops and places more spoil on top of the mined out area. This technique reduces the required volume of hollow fill areas.

Finger-Ridge Mining. Finger-ridge removal methods can also utilize cross-ridge mining techniques. Finger-ridge mining is similar to mountaintop mining; however, instead of removing the entire mountain or hill above the coal seam(s), only the ridges or incremental parts of the mountain above the coal seam(s) are removed. This allows operators to take advantage of lower stripping ratios in ridge areas. The final highwall, which often represents economic cutoff, occurs where the strip ratio becomes too high as mining progresses into the mountain. The block of coal that remains could be mined later if economic conditions become favorable or new techniques are developed.

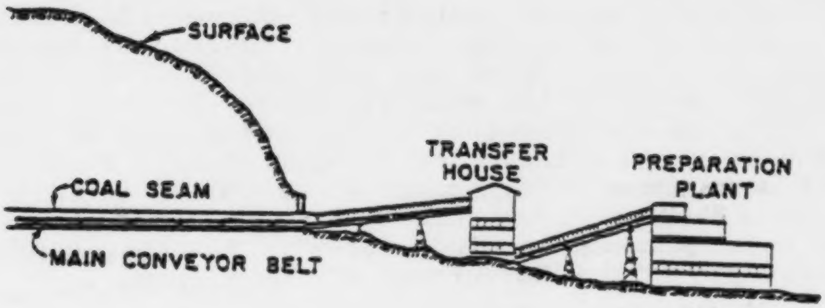
Underground Mining

Underground methods are employed where the coal is too deep to be surface mined economically or environmental restrictions preclude surface mining. Basically, there are three types of underground mines according to the manner in which the opening from the surface to the coal seam is made. These include drift mines, slope mines, and shaft mines (see Figure IV-24). In a drift mine, the opening into the coal is horizontal or made directly into the seam at a point where it outcrops on the surface. A slope mine uses an inclined opening to reach the coal. A slope entry is usually employed where the coal seam is at an intermediate depth (there is no visible outcrop), or where the coal outcrop condition is unsatisfactory or unsafe for drift entry. Shaft mines are usually developed when the coal seam lies deep underground.

Conventional

This method extracts the coal in a sequence of operations, with special equipment to execute each step. First, the coal is cut by a cutting machine and then drilled, loaded with explosives, and blasted. The broken coal is gathered by a loading machine and transported to a shuttle car (or in some cases, the coal is both gathered and transported by specially designed equipment), which dumps the coal onto a conveyor belt or a mine car loadout station. A machine follows closely behind the operating face installing roof bolts, or other roof support items such as timbers or steel crossbars are installed. This type of mining system is gradually being phased out in U.S. mines and is being replaced by continuous mining machines. Figure IV-25 illustrates room and pillar mining by conventional methods.

DRIFT MINE


SURFACE
TRANSFER HOUSE
PREPARATION PLANT
COAL SEAM
MAIN CONVEYOR BELT

SLOPE MINE

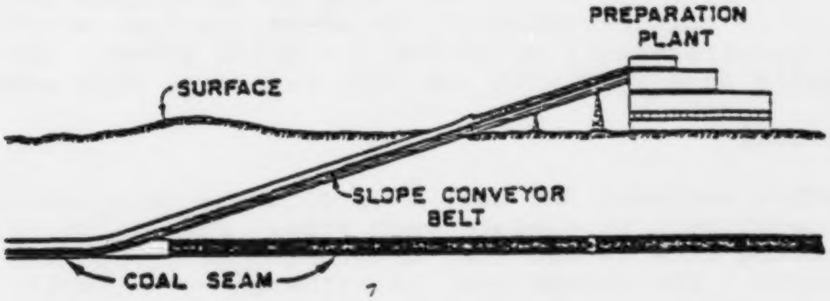

PREPARATION PLANT
SURFACE
SLOPE CONVEYOR BELT
COAL SEAM

Figure IV-24

UNDERGROUND MINING PRACTICES

Reprinted from "Elements of Practical Coal Mining," by Samuel M. Cassidy, editor, 1973, by permission of the Society of Mining Engineers of AIME.

SHAFT MINE

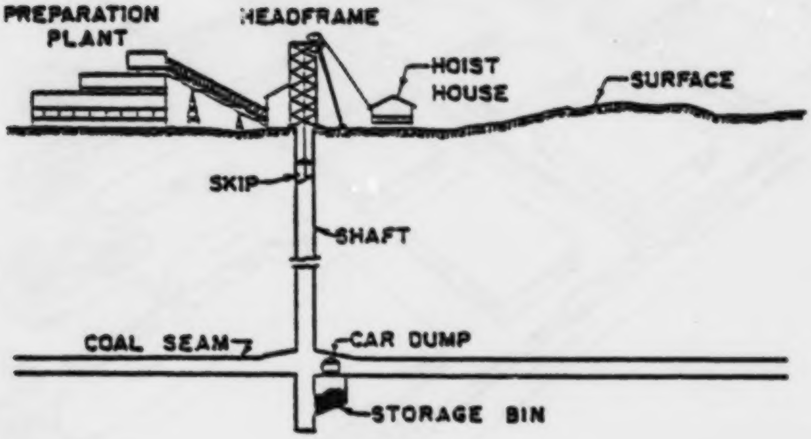

PREPARATION PLANT
HEADFRAME
HOIST HOUSE
SURFACE
SKIP
SHAFT
COAL SEAM
CAR DUMP
STORAGE BIN

Figure IV-24 (Continued)

UNDERGROUND MINING PRACTICES

Reprinted from "Elements of Practical Coal Mining," by Samuel M. Cassidy, editor, 1973, by permission of the Society of Mining Engineers of AIME.

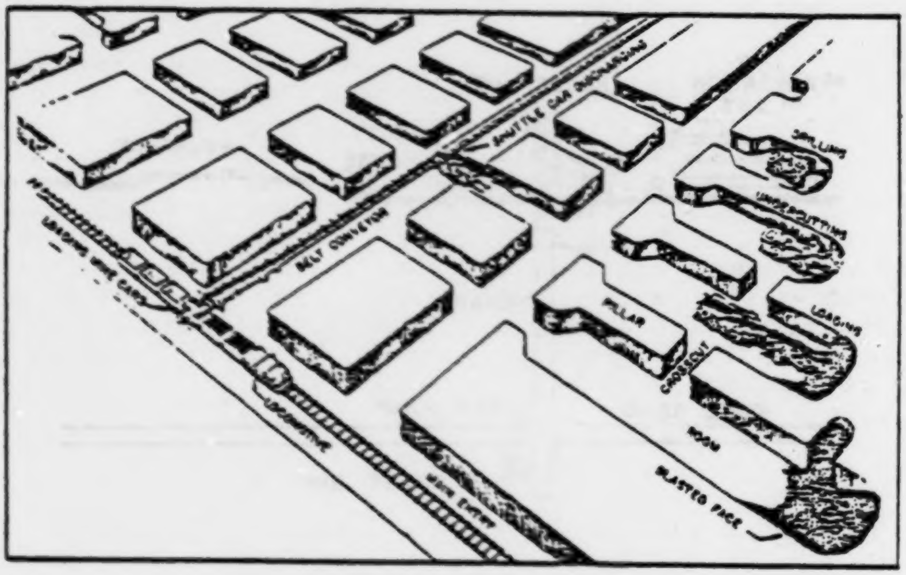

SHUTTLE CAR DISCHARGING
DRILLING
UNDERCUTTING
LOADING MINE CARS
BELT CONVEYOR
PILLAR
LOADING
CROSSCUT
LOCOMOTIVE
ROOM
MAIN ENTRY
BLASTED FACE

Figure IV-25

UNDERGROUND COAL MINING - ROOM-AND-PILLAR SYSTEM
(Conventional Method)

Reprinted, with permission, from "Coal in America," by Richard A. Schmidt. Copyright 1979, McGraw-Hill, Inc.

Source: U.S. Bureau of Mines

Continuous

This method utilizes a single machine called a "continuous miner" which breaks the coal mechanically, then loads and transports it to a shuttle car. The shuttle car transports the coal to a conveyor belt for passage out of the mine. A roof bolting machine is usually scheduled to follow closely behind the operating face. Recently, development towards continuous haulage has been emphasized whereby the conveyor belt system connects directly to the continuous miner; also, mounting roof bolting equipment on continuous miners has been explored. These developments are likely to further improve productivity and safety.

Both the conventional and continuous mining methods use the room and pillar technique to extract the coal. Main tunnels, or headings, are first driven from the point of entry into the coal seam. From these main headings, secondary headings are driven perpendicularly. Blocks of coal are then extracted in a systematic pattern along both sides of the headings, and pillars of intact coal are left between the mined-out rooms to support the mine roof and prevent surface subsidence above the workings. Once a given area or entire mine property has been developed, retreat mining is often practiced in which additional coal is mined from the pillars, thereby increasing overall coal recovery. Room and pillar mining normally achieves extraction of 40 to 60 percent of the coal seam.

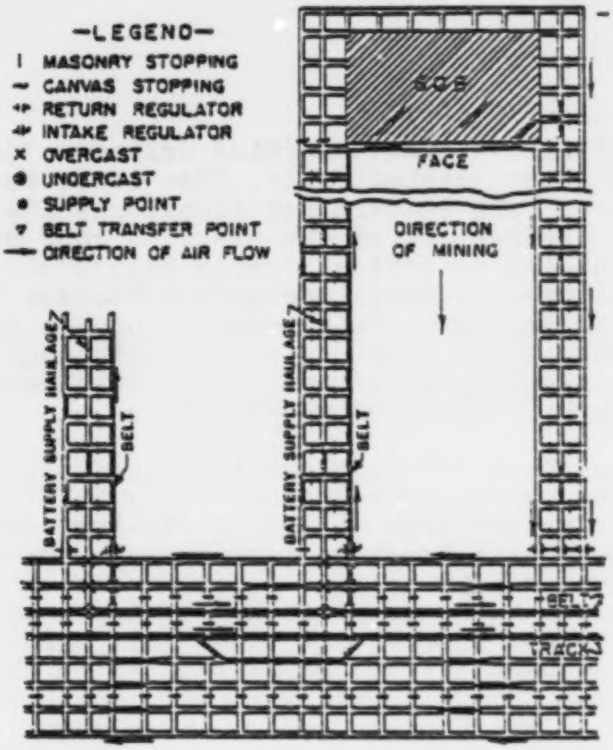
Longwall

Longwall mining is relatively new to the mining industry. This system mines large blocks of coal, outlined during the mine development phase, which are completely extracted in a single, continuous operation. Longwall mining machines utilize coal cutters that move across a section of the face and the cut coal falls onto a continuously moving face conveyor. Hydraulic roof supports are advanced with each pass of the cutter, permitting controlled roof collapse as mining progresses. Longwall mining, once properly implemented, is usually highly productive and allows increased recovery of the coal since it is unnecessary to leave pillars of coal for roof support as in other mining methods. One quarter of western deep mines currently use longwalls. Longwall mining techniques are illustrated in Figure IV-26.

Shortwall

This new mining method, introduced from Australian mines, represents a combination of the continuous mining and longwall systems. Either continuous mining equipment or conventional equipment is used to develop the field. A continuous miner, in conjunction with the longwall-type roof supports, is then used to

UNDERGROUND MINING PLAN FOR LONGWALL DEVELOPMENT MINERS


—LEGEND—
I MASONRY STOPPING
— CANVAS STOPPING
RETURN REGULATOR
INTAKE REGULATOR
× OVERCAST
● UNDERCAST
• SUPPLY POINT
▾ BELT TRANSFER POINT
— DIRECTION OF AIR FLOW
GOB
FACE
DIRECTION OF MINING
BATTERY SUPPLY HAULAGE
BELT
BATTERY SUPPLY HAULAGE
BELT
BELT
TRACKS

PLAN OF THE LONGWALL FACE THAT IS SHOWN ABOVE

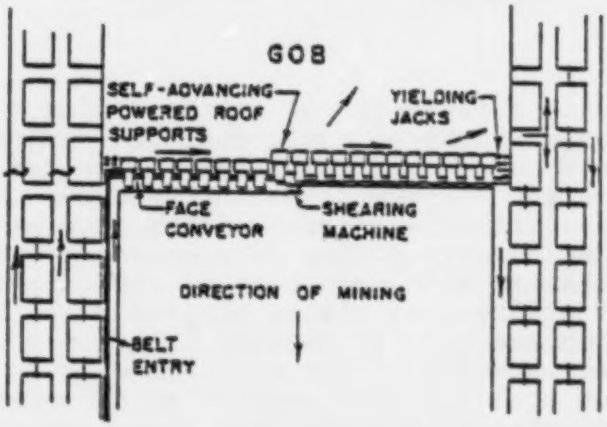

GOB
SELF-ADVANCING POWERED ROOF SUPPORTS
YIELDING JACKS
FACE CONVEYOR
SHEARING MACHINE
DIRECTION OF MINING
BELT ENTRY

Figure IV-26
LONGWALL MINING METHOD

Reprinted from "Elements of Practical Coal Mining," by Samuel M. Cassidy, editor, 1973, by permission of the Society of Mining Engineers of AIME.

extract the remaining coal pillars. The individual pillars or blocks of coal are somewhat smaller than those in longwall operations. Transportation of the coal may be by shuttle cars or by newly developed portable, flexible belt conveyors that follow the continuous miner in and out (i.e., continuous haulage). As in longwall mining, shortwall mining also offers improved coal recovery. Shortwall mining techniques are illustrated in Figure IV-27.

PREPARATION PLANTS AND ASSOCIATED AREAS

Introduction

Coal preparation is the process of upgrading raw coal by physical means. In general, preparation techniques improve the heating value and physical characteristics of the coal by removing impurities such as pyrite and ash material (e.g., shales, clays, shaley coals, etc.). By removing potential pollutants such as sulfur-bearing minerals prior to combustions, coal cleaning can be an important control strategy for complying with air quality standards.

The physical upgrading of metallurgical coal has long been a necessity because the steel industry has had the toughest quality requirements of all major coal-consuming industries. On the other hand, utility (steam) coal has been subjected to less extensive preparation. Although utility coal is required to be relatively uniform in size, the economic benefits accrued from deep cleaning in the past has not been sufficient to justify the additional preparation costs. However, with the establishment of new sulfur dioxide emission standards for power generating plants, there is a growing demand for more complete cleaning of utility coal. Electric utility companies can meet these standards by installing scrubbers or other technologies that reduce the sulfur content of stack gases, or by burning cleaner, lower sulfur coal.

Coal Preparation Processes

The physical coal cleaning processes used today are oriented toward product standardization and reduction of ash, with increasing attention being placed on sulfur reduction. In a modern coal-cleaning plant, the coal is typically subjected to size reduction and screening, gravity separation of coal from its impurities, and dewatering and drying.

The commercial practice of coal cleaning is primarily based on separation of the impurities due to differences in the specific gravity of coal constituents (i.e., gravity separation processes), and on the differences in surface properties of the coal and its mineral matter (i.e., froth flotation).

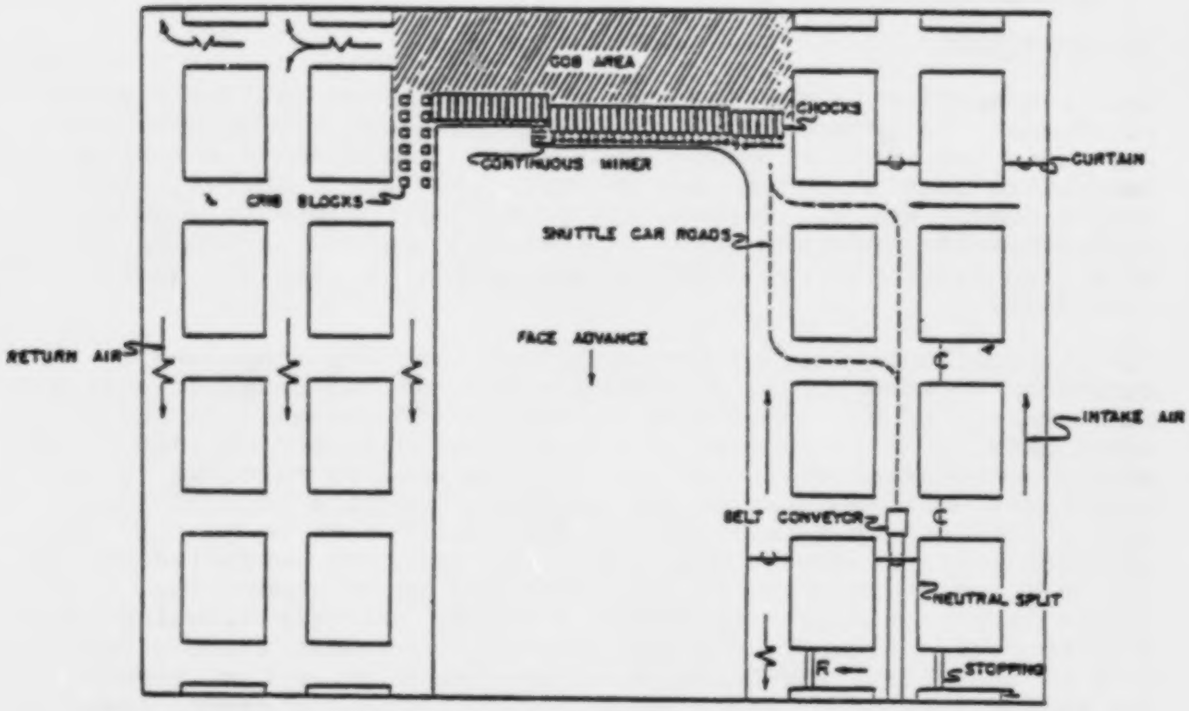

GOB AREA
CHOCKS
CURTAIN
CONTINUOUS MINER
CRIB BLOCKS
SHUTTLE CAR ROADS
FACE ADVANCE
RETURN AIR
INTAKE AIR
C
C
BELT CONVEYOR
NEUTRAL SPLIT
R
STOPPING

Figure IV-27

SHORTWALL MINING METHOD
(An experimental plan for shortwall mining in eastern Kentucky)

Reprinted from "Elements of Practical Coal Mining," by Samuel M. Cassidy, editor, 1973, by permission of the Society of Mining Engineers of AIME.

Although it is not possible to describe a universal coal preparation process, certain processing methods common to most preparation operations can be identified. Figure IV-28 illustrates a coal-cleaning facility that uses common process methods, without detailing specific unit operations.

Initial Coal Preparation

Prior to the actual cleaning process, run-of-mine coal must undergo initial preparation. This involves preliminary crushing of the coal to remove large rock fractions and to liberate entrained impurities such as clay, rock, and other inorganic materials, including pyrite. The first crushing step is followed by a screening operation and secondary crushing. A second screening step produces two product streams from this process area: one containing a fine fraction (usually less than 6.5 mm) and the other containing coarse particles (normally 76.0 x 6.5 mm). These two coal streams are then routed to their respective process areas where the actual cleaning operation takes place (7).

Fine Coal Processing

Fine coal processing can involve either wet or dry cleaning methods. In plants utilizing a dry coal cleaning process, fine coal from the initial preparation step flows to a feed hopper and then to an air cleaning operation. This cleaning operation can employ one of several devices which rely on an upward current of air traveling through a fluidized bed of crushed coal. Separation is effected by particle size and density. Product streams from a dry cleaning process are sent directly to the final coal preparation step, while reject streams are usually processed further in wet cleaning operations (21).

In operations utilizing wet methods to effect fine coal cleaning, the process feed stream containing less than 6.5 mm coal is slurried with water as it enters the fine coal processing area of the plant. This slurry is then subjected to a desliming operation which removes a suspension containing approximately 50 percent of minus 200 mesh material. The cutoff size for this separation is usually in the range of 28 to 48 mesh. This desliming operation is necessary because the presence of slimes adversely affects the capacity and efficiency of fine cleaning units (21).

Subsequent to desliming, the oversize coal fraction (greater than 28 mesh) is pumped to the fine coal cleaning process. Here, fine coal particles undergo gravity separation in one of several wet cleaning devices. This removes a percentage of ash and pyritic sulfur to produce a clean coal product. The product stream from

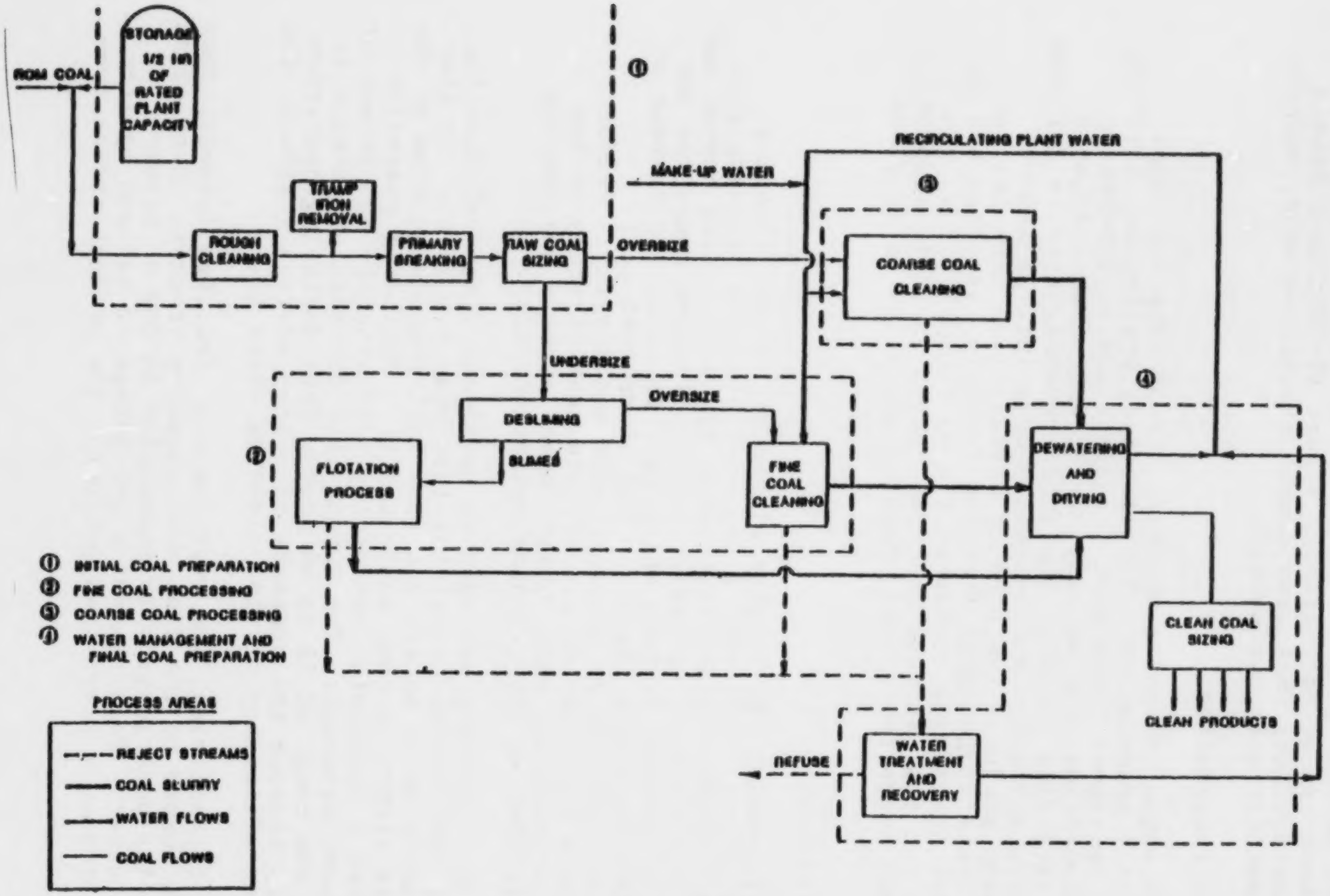

ROM COAL
STORAGE 1/2 HR OF RATED PLANT CAPACITY
①
ROUGH CLEANING
TRAMP IRON REMOVAL
PRIMARY BREAKING
RAW COAL SIZING
OVERSIZE
MAKE-UP WATER
RECIRCULATING PLANT WATER
③
COARSE COAL CLEANING
UNDERSIZE
④
DESLIMING
OVERSIZE
SLIMES
②
FLOTATION PROCESS
FINE COAL CLEANING
DEWATERING AND DRYING
CLEAN COAL SIZING
CLEAN PRODUCTS
WATER TREATMENT AND RECOVERY
REFUSE
① INITIAL COAL PREPARATION
② FINE COAL PROCESSING
③ COARSE COAL PROCESSING
④ WATER MANAGEMENT AND FINAL COAL PREPARATION
PROCESS AREAS
REJECT STREAMS
COAL SLURRY
WATER FLOWS
COAL FLOWS

Figure IV-28

SIMPLIFIED FLOW SCHEME--PHYSICAL COAL CLEANING PROCESS

Source: "The Energy Requirements for Control SO_x Emissions from Coal
Electric Generators," Radian Corporation, DCN-77
No. 68-02-2608, U.S. EPA-IERL, 1977.

this operation is fed to the drying area of the plant; refuse material is further processed in the water treatment section.

The slimes removed from the fine coal stream are fed to a froth flotation process. Other material, such as reject from dry cleaning operations, may also be treated in the flotation process. This process consists of "rougher" and "cleaner" sections which are comprised of cells of flotation machines. Upon entering the flotation process area, the slime suspension is treated with a frothing agent. This agent selectively floats coal particles in the flotation machines while allowing pyrite and ash impurities to settle. Processing slime in the "rougher" cells produces a reject stream and a low-grade product. The low-grade product is further processed in the "cleaner" cells to produce a clean coal product. This final float product is then sent to the dewatering area for further handling, while reject material from both rougher and cleaner sections is processed in the water treatment and recovery area.

Coarse Coal Processing

Feed to the coarse coal processing area of the plant consists of oversize material (76 x 6.5 mm particles) from the initial preparation area. This feed stream is slurried with water prior to cleaning, since coarse coal cleaning operations employ wet processing equipment to remove impurities from the coal. The coarse coal slurry is fed to one of the many types of process equipment currently employed in coarse coal cleaning. Here, impurities are separated from the coal due to differences in product and reject density. It is common practice to remove a middling fraction from the separation operation and process it further by means of recycle or by feed to another cleaning process. These cleaning operations result in removal of two streams from the coarse coal processing area: a product and a reject stream. Subsequent to the coarse cleaning operation, the product stream is pumped to the dewatering and drying area of the plant, while the reject stream is processed in the water treatment recovery area.

Water Management/Refuse Disposal

Dewatering and drying equipment handle the product flows from both the fine and coarse coal preparation areas. Typically, cleaning plants employ mechanical dewatering operations to separate coal slurries into a low-moisture solid and clarified supernatant. The solid coal sludge produced in the dewatering step can be mechanically or thermally dried to further reduce the moisture. The supernatant from the dewatering process is returned to the plant water circulation system.

The water treatment and recovery section of a cleaning plant processes refuse slurries containing both coarse material and reject slimes. Here, the refuse slurry is dewatered, typically in thickeners and settling ponds. The supernatant from this operation is returned for reuse in the plant, while the refuse can be buried and revegetated to prevent burning, or piled prior to reclamation.

The coal product from the dewatering and drying area of the plant often undergoes additional processing. This may involve crushing and screening operations to separate the product into various product sizes. The cleaned and sized product is then conveyed to storage silos or bins prior to shipping.

Plant Statistics

There was a total of 458 preparation plants processing anthracite, bituminous, and lignite coal in the United States in 1975 (20). (Current estimates (1979) indicate there are now approximately 670 preparation plants.) Based on 1976 data, 95 percent of the plants employed wet processing methods (see Figure IV-29). Only 21 plants used dry methods. Two-thirds of the wet processing plants utilized heavy media separation, froth flotation, or both.

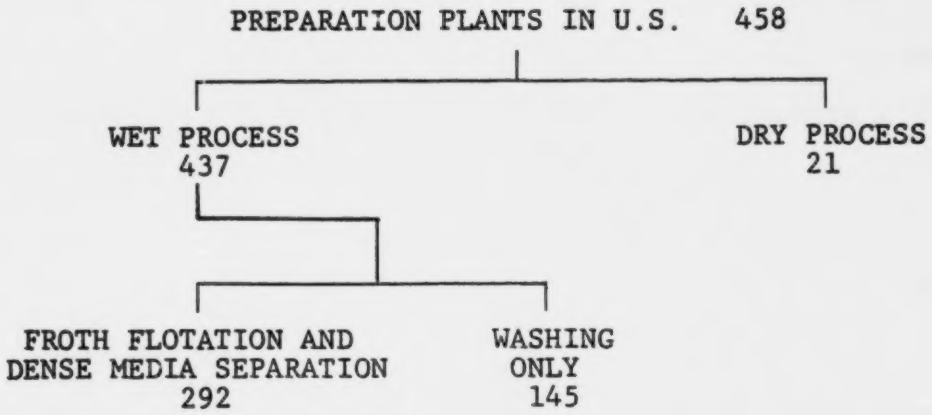
Table IV-14 shows bituminous and lignite tonnage processed in 1975 by type of cleaning method. Two hundred and forty-two million metric tons (267 million short tons) (41 percent) of 1975 production received mechanical cleaning using wet processing methods, whereas 288 million metric tons (317 million short tons) (49 percent) were subjected to crushing and/or screening only and 58 million metric tons (64 million short tons) (10 percent) received no processing prior to consumption.

Table IV-15 breaks down mechanical cleaning of bituminous and lignite coal by type of equipment.

Associated Areas

Associated areas include coal slurry ponds, refuse piles, raw and clean coal stockpiles, applicable haulroads or access roads, and disturbed areas from preparation plant facilities; that is, areas associated with the preparation of and waste generated by a refined coal product.

Mainly refuse piles and coal stockpiles, plus other associated areas, can be prone to generation of acid waters, especially if high pyritic coals are involved. Proper management and treatment techniques are required to be used to minimize water pollution from these areas.



PREPARATION PLANTS IN U.S. 458
WET PROCESS 437
DRY PROCESS 21
FROTH FLOTATION AND DENSE MEDIA SEPARATION 292
WASHING ONLY 145

Figure IV-29

TYPES OF COAL PREPARATION PLANTS IN THE UNITED STATES

Source: (20)

Table IV-14

BITUMINOUS COAL AND LIGNITE TONNAGE PROCESSED IN 1975

Type of Cleaning Method	kkg ÷ 10^6	Short Tons ÷ 10^6	Percent
Mechanical processing	242	267	41
Crushed or screened	288	317	49
No processing	58	64	10
Total 1975 production	588	648	100

Source (19)

Table IV-15

MECHANICAL CLEANING OF BITUMINOUS AND LIGNITE COAL IN 1975, BY TYPE OF EQUIPMENT

Type of Equipment	kkg ÷ 10^6	Short Tons ÷ 10^6	Percent
Washing Only Processes			
Jigs	113.0	124.3	46.6
Concentrating Tables	26.0	28.7	10.7
Classifiers	5.6	6.2	2.3
Launderers	2.4	2.7	1.0
Subtotal	147.0	161.9	60.6
Dense Media Processes			
Magnetite	65.7	72.4	27.1
Sand	12.2	13.5	5.1
Calcium Chloride	0.9	1.0	0.4
Subtotal	78.8	86.9	32.6
Flotation	10.4	11.5	4.3
Total Wet Methods	236.2	260.3	36.9
Pneumatic Methods	6.1	6.7	2.5
Grand Total	242.3	267.0	100.0

Source (19)

SECTION V

WASTEWATER CHARACTERIZATION AND INDUSTRY SUBCATEGORIZATION

INTRODUCTION

The development of effluent limitations guidelines is based upon the determination of the effluent characteristics of the industrial category and the identification of suitable treatment technologies for reduction of pollutants within the category. All industrial categories have inherent processing, site, or raw material differences which influence their effluent characteristics and methods of wastewater treatment. The purpose of this section is to recognize any of these major inherent differences that exist within the category, and more importantly, to determine their impact on treatability and effluent characteristics. The subcategorization scheme developed from this evaluation provides the basis for the selection of treatment technologies and the determination of effluent standards.

SUBCATEGORIZATION

The development of the BAT subcategorization scheme includes an examination of many factors which might affect effluent quality and treatability. The factors examined include mine type (surface or underground), coal type (anthracite, bituminous, lignite), size, location, and effluent source (preparation plant, active mine, or reclamation area). These factors were previously examined during the development of BPT effluent limitations, and a BPT subcategorization scheme was established. That subcategorization has been reexamined in light of additional data collected during the BAT program. Statistical and engineering analyses of these data indicate that several modifications are appropriate.

Revised BPT and BAT Subcategorization Scheme

The following categorization provides the basis for the remainder of this study:

1. Preparation Plants and Associated Areas
2. Acid Mine Drainage
3. Alkaline Mine Drainage
4. Post Mining Discharges
    a. Reclamation areas and
    b. Underground mine dicharges.

A review of the subcategorization scheme for new sources was also performed. As a result of treatment system design considerations and the cost of implementation (both of which are discussed more fully at the end of this section), a separate subcategory for

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preparation plant associated areas was established for new sources. Thus, the following subcategorization is proposed for new sources:

1. Preparation Plants
2. Preparation Plant Associated Areas
3. Acid Mine Drainage
4. Alkaline Mine Drainage
5. Post Mining Discharges
    a. Reclamation Areas
    b. Underground Mine Discharges

The rationale for the modified BPT, BAT, and NSPS subcategorizations appear at the end of this section.

SAMPLING AND ANALYSIS PROGRAM

To support the proposed regulations, data characterizing wastewaters generated during the extraction and preparation of coal were obtained and evaluated. The initial data collection effort was instituted during 1974 and 1975 for the development of BPT effluent limitations required to be established under the Federal Water Pollution Control Act of 1972. These data included results from a sampling and analysis program and assimilation of a large amount of historical data supplied by the industry, the U.S. Bureau of Mines and other sources. This information characterized wastewaters from coal mining operations according to a number of key control parameters--acidity, alkalinity, total suspended solids, pH, iron, and others. However, little information on other pollutants such as toxic metals and organics were available from industry or government sources. To establish the levels of these pollutants, a second sampling and analysis program was instituted to specifically address these toxic compounds, including the 65 pollutants and pollutant classes for which regulation was mandated by the Clean Water Act Amendments of 1977. These pollutants are listed on Table VI-1.* This sampling effort also served to extend the coal wastewater data base of conventional and nonconventional pollutants.

Data Base Developed During This Study

The Agency instituted a screening sampling program and a verification sampling program directed primarily at determining levels of the toxic pollutants in raw and BPT-treated effluents in the coal mining industry. Additional analytical data were obtained during engineering site visits to seventeen mine sites. Two EPA regional offices supplied supporting data from facilities within their geographical areas. Data generated from a self-monitoring program for areas under reclamation are also part of the data base. Finally, data from a preparation plant industry questionnaire and NPDES Discharge Monitoring Reports from four EPA regions have been compiled for addition to the active data base. These data sources are presented, by proposed subcategory, in Table V-1 and discussed in more detail below. Table V-2 summarizes statistics for the data base upon which coal industry wastewaters are characterized.

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*Tables and figures appear at the end of the section.

A number of treatability studies were also conducted to evaluate the capacity of candidate technologies to treat coal mine drainage. These studies are summarized in Table V-3. Results from the treatability studies are discussed in detail in Section VII, Treatment and Control Technologies.

Data Sources

Screening and Verification Sampling

The screening and verification sampling program began in 1977. Several criteria were considered in the selection of sampling sites. It was determined that facilities to be sampled should:

1. Be representative of the industry to account for all major factors (i.e., location, topography, seam characteristics, etc.) which could influence effluent quality and treatability; and

2. Include treatment processes considered exemplary within the industry to establish a baseline for best available technologies.

Applying these criteria, a candidate list of sites was prepared and submitted to the Water Quality Committee of the National Coal Association for comment. A final list of sites to be visited for the screening phase was then compiled. The mine companies were contacted and sampling arrangements made. Screening sampling visits were conducted during 1977 to sites within the various subcategories as listed in Table V-1. All sampling and analysis during this phase were done according to EPA sampling protocols (8)

After review of screen sampling analytical results, several additional sites were selected for verification sampling. Three coal mines and preparation plants were revisited to verify data collected during screening. Three additional bituminous and lignite mines, as well as four anthracite facilities, were also sampled to enhance the representativeness of the data base. Sampling and analytical protocols for this phase were all in accordance with EPA procedures (8). More detail on these protocols can be found in Appendix C.

Engineering Site Visits

The engineering site visits were carried out primarily to collect cost data for verifying and supplementing costs previously developed for the coal mining industry. Fourteen separate mines, some with an associated preparation plant, were contacted and visited in the fall of 1979. A sample data checklist used on the visits may be found in Appendix D. Grab samples of raw and treated effluents were collected and shipped for analysis of "classical" parameters (TSS, Fe, Mn, pH, turbidity, alkalinity/acidity, settleable solids, and total dissolved solids) and the thirteen toxic metals. The analytical protocol used was established by EPA. The metals were analyzed by inductively-coupled argon-plasma emission spectrometry and atomic adsorption (9).

EPA Regional Support Studies

EPA Region 8 (Denver, Colorado) instituted a sampling effort to assess the water treatment configurations and effluent qualities characteristic of the western coal producing region. Several mines were visited during the spring of 1979; however, due to an unusually mild winter and an abnormally dry spring, only two of those contacted were found to have a discharge that could be sampled. Grab samples were collected and analyzed for the currently regulated parameters, priority metals, and a number of nonconventional pollutants. EPA Region 4 (Atlanta, Georgia) conducted a similar effort at one mine in its region. These data were forwarded to the Effluent Guidelines Division and incorporated into the data base. This information was used to further characterize mine drainage and wastewater treatability, particularly for priority metals removal.

Preparation Plant Industry Survey

This study was conducted with the cooperation of the National Coal Association (NCA) to assess water usage and treatment in coal preparation plants. NCA producer companies were mailed a questionnaire requesting the following information: facility profile, water balance around the preparation facility, makeup water sources, discharge points and quantities, water treatment practices employed, water management procedures and acreage of preparation plant associated areas, and effluent quality data. A sample questionnaire is in Appendix D. Fifty-nine companies representing 152 plants (approximately 50 percent of the NCA producer company prepartion plants) responded to the survey, representing roughly 30 percent of all the plants in the industry. This information was incorporated into the computer data base developed in support of the overall program, and may be found in Appendix E. The uses of the industry responses include the following:

1. Determination of the number of plants operating a total recycle system;

2. Determination of requirements for modifying current treatment configurations to a total recycle system; and

3. Determination of the runoff treatment strategy for areas ancillary to the preparation plant.

Questionnaire results are discussed in Section VII, Treatment and Control Technology.

Self-Monitoring Survey

A survey conducted under authority of Section 308 of the Clean Water Act is currently underway at 12 mine companies, with a total of 21 sedimentation ponds. The purpose of this study is to supplement the data base upon which effluent standards will be based for runoff primarily from mining areas upon which revegetation has commenced. This survey contains effluent quality data during base flow conditions, and during and after rainfall events. Samples are taken of the influent and effluent to the pond. One sample per week is collected to establish base flow conditions, with additional samples taken during any significant rainfall event and the day after the rainfall event. The results of these sample analyses, coupled with design specifications submitted by the participating companies for each pond, permit identification of the treatment effectiveness of these ponds during dry weather and storm conditions, as well as concentrations of pollutants which characterize runoff from mine reclamation areas. The parameters analyzed include total suspended solids, settleable solids, total iron, dissolved iron, and pH. Certain samples were also analyzed for the priority metals.

Site Specific Reclamation Area Study

A second major sampling program to characterize runoff from reclamation areas and storm provisions has been commissioned by EPA and the Office of Surface Mining Reclamation and Enforcement in the Department of the Interior. Approximately thirty-nine mine sites have been chosen from major coal-producing regions of the country for a survey of reclamation and sediment control techniques to establish the relationship of those techniques to effluent water quality. Detailed, daily information on the physical and chemical quality, flow, and sediment load of drainage from eight sites will also be collected during the study. Where possible, an hourly record will be taken during precipitation events to document drainage quality and sediment pond efficiency during runoff periods at these eight sites. This study is expected to be completed in mid-1981.

Preparation Plant Sampling Program

This sampling and analysis effort was instituted to characterize preparation plant effluents and to compare wastewater generated within total recycle systems with wastewater discharged from partial recycle and once-through systems. Grab samples were collected at three preparation plants and associated areas and analyzed according to Agency protocol (8). Cost and wastewater engineering data were collected simultaneously to augment present data and to permit an evaluation of the feasibility of no discharge of pollutants from preparation plant water circuits.

Regional Discharge Monitoring Reports (DMR) Filed Under the NPDES Program

A program has been initiated to collect DMRs from EPA regional offices located in the major coal producing areas in the United States. These data identify the levels of variation in flow and pollutant characteristics associated with mine drainage. Of particular interest is the daily maximum value of each regulated pollutant (TSS, Fe, Mn, and pH) during the 30-day monitoring period. Eighty-eight sets of data were obtained from EPA Regions 3, 4, 5, and 8.

WASTEWATER SOURCES AND CHARACTERISTICS

Water enters surface or deep mines by groundwater infiltration, precipitation, and surface runoff. Surface runoff can become contaminated with suspended solids from sediment. If pyritic material is exposed on the mine bottom, highwall, or spoil piles, oxidation and acid formation can occur and leach toxic metals. Groundwater entering a surface or deep mine is also subject to acid formation.

The wastewater situation at coal mines is notably different from that found in most other industries. No process water is used in coal extraction, except for minor use in dust suppression, equipment cooling, and firefighting needs. Water is an operational hindrance to a coal mine, and requires careful management to minimize water entering the active mining area. Water can cause occupational health hazards, such as spoil bank or highwall instability or an electrical short circuit in the case of operations using electric trunk lines to power mining equipment.

As indicated in the industry profile section, the quantities of water generated at a mine site do not correlate with the coal production rate. This again differs from most other industries, where flow, and thus pollutant loadings, can be linked with the rate of production.

A final major difference with water management in the coal industry is the possibility of continuing discharges of polluted wastewater after the facility has ceased production, especially from underground operations. Control practices, which are discussed in Section VII, can be implemented to minimize or treat these discharges during and after the active mining phase.

This subsection will summarize raw wastewater data first for all subcategories and then for each individual proposed subcategory. The data sources in the summary tables include the following:

1. Screening sampling data,
2. Verification sampling data,
3. Self-monitoring survey data,
4. EPA regional data,
5. Engineering site visits, and
6. Preparation plant site visits.

A number of explanatory points should be made to correctly interpret the tables presented in this section and the next section. First, all concentrations are presented in micrograms per liter, listed as UG/L on the tables.

Second, the tables represent an effort to illustrate the quantity and distribution of the data. Thus, the total number of samples analyzed for each pollutant parameter is listed in the first numerical column. The second column presents the total number of times the pollutant was detected during analysis. Because the Agency considers 10 ug/l as a realistic lower limit for detection of organic compounds (5 ug/l for pesticides), the third column depicts the total number of samples where a detected value of greater than 10 ug/l was found. These are termed "quantifiable levels." The final six columns are an attempt to illustrate the data distribution of only the detected values. The statistics listed include the minimum, the 10 percent value (i.e., 90 percent of the detected values are above this concentration), the median of detected values, the mean of detected values, the 90 percent value (90 percent of the detected values are below this value), and the maximum reported concentration. Nearly all the organic priority pollutants and a number of the toxic metal pollutants are most frequently found as "not detected," i.e., below the detection limit. To record these values on the final five columns would render these columns essentially meaningless. For instance, cyanide was detected in only three samples out of 50 for raw wastewater (see Table V-4). If the not detected values were recorded in the final five columns, the minimum, the 10 percent value, the median, and the 90 percent value would all be listed as not detected. This may be appropriate for some types of evaluation, but, for the purpose of developing treatment technologies and supporting a subcategorization scheme, illustrating the data distribution for detected values is more informative.

Third, in situations where fewer than 10 detected values occur, no meaningful number could be selected to represent the 10 percent and 90 percent values. This is denoted by an asterisk. Dots in the minimum, mean, median, and maximum columns indicate no values were detected for that parameter.

Fourth, concentrations were sometimes reported by the analytical laboratory as "detected less than X" where X equals some detection limit. This apparently contradictory information can be explained by evaluating common laboratory procedures. The analytical machines used for these samples frequently have a significant degree of background noise, often due to 60 Hz electrical frequencies and internal electrical phenomena which on the readout can partially or totally mask the signature of a compound. This level of noise is one factor which is accounted for in the determination of the detection limit. In most laboratory analyses, the signatures of the desired compounds that are partially masked can be identified by a skilled lab technician. The concentration is thus reported as being detected, but at less than the detection limit. For computational purposes, a method for quantifying these detected values is needed. Thus, in the accompanying tables, for values reported as "detected less than X," where X equals some detection limit, the value was calculated and recorded on the table as 1/2 of X when X was less than 4 ug/l and as the square root of X when X was greater than 4 ug/l.

Fifth, some values were too large to put in a column in decimal notation; these are recorded in exponential notation with an "E" prior to an integer number of zeros. For example, on the sixth page of Table V-4 for the total suspended solids mean value, a level of 1016E4 is recorded. This should be interpreted as 1,016 x 10^3 or as 1,016,000 ug/l.

Sixth, to accurately analyze the data, factors which could bias the data should be minimized or eliminated. Two particular instances should be noted. First, each piece of data is coded according to a number of identifying parameters, one of which is its sample type (e.g., raw wasteload, partially treated stream, final discharge). To include multiple analyses of the same raw effluent source would be redundant and introduce bias. Thus, for four facilities (00013, 00014, 00009, 00010), multiple raw effluent points were averaged for each facility to yield one raw effluent data point per facility. A second similar situation occurred when multiple samples were taken of the same sample point over a period of days. For instance, three days of verification sampling of the same point were averaged to yield one distinct data point before statistical calculations were performed. This also avoids unnecessary bias.

Finally, three pairs of priority organic compounds cannot be distinguished using GC/MS equipment. They are anthracene/phenanthrene, benzo(a)anthracene/chrysene, and benzo(3,4) fluoranthene/benzo(k)fluoranthene (abbreviated on the table as benzo(3,4/k)fluoranthene). The dual compounds are reported prior to the priority metals data as one concentration value for each pair.

The data for raw wastewater from coal mines for all proposed subcategories are summarized in Table V-4. This table permits an overview of the characterization of mine drainage. The following subsections present sources and data on raw effluent for each proposed subcategory.

Acid Mine Drainage

Formation of Acid Mine Drainage

Iron sulfide, or pyrite, is a common substance formed from mineral sulfur. It is this sulfur-containing compound that is a precursor to acid mine drainage. As water drains across or percolates through pyritic material, in the presence of oxygen, the formation of acid drainage occurs in two steps (11, 12). The products of the first step are ferrous iron and sulfuric acid as shown in equation 1.

$$2FeS_2 + 7O_2 + 2\ H_2O = 2FeSO_4 + 2H_2SO_4 \quad (1)$$

The ferrous iron (Fe^{+2}) then undergoes oxidation to the ferric state (Fe^{+3}) as shown in equation 2.

$$4FeSO_4 + 2H_2SO_4 + O_2 = 2Fe_2(SO_4)_3 + 2H_2O \ (2)$$

The reaction may proceed to form ferric hydroxide or basic ferric sulfate as shown in equations 3 and 4 respectively.

$$Fe_2(SO_4)_3 + 6H_2O = 2Fe(OH)_3 + 3H_2SO_4 \quad (3)$$

$$Fe_2(SO_4)_3 + 2H_2O = 2Fe(OH(SO_4)) + H_2SO_4 \quad (4)$$

The ferric iron can also directly oxidize pyrite to produce more ferrous iron and sulfuric acid as shown in equation 5.

$$FeS_2 + 14Fe^{+3} + 8H_2O=15Fe^{+2} + 2SO_4^{-2} + 16H^{+}(5)$$

Thus, the oxidation of one mole of iron pyrite yields two moles of sulfuric acid. As the pH of the pyritic systems decreases below five, certain acidophilic, chemoautotrophic bacteria become active. These bacteria, Thiobacillus ferroxidans, Ferrobacillus ferroxidans, Metallogenium, and similar species are active at pH 2.0 to 4.5 and use CO_2 as their carbon source (19). These bacteria are responsible for the oxidation of ferrous iron to the ferric state, the rate limiting step in the oxidation of pyrite. Their presence is generally an indication of rapid pyrite oxidation and is accompanied by waters low in pH and high in iron, manganese, and total dissolved solids.

The acid formed from these reactions is an effective extraction agent, causing trace elements to be leached and dissolved into solution. The solubilities of these substances, mostly heavy metals, are very sensitive to changes in pH. This is illustrated in Figure V-1. The data on this figure are derived from an experimental study of acid mine drainage (7).

Acid drainage can be readily formed by rainfall upon either a coal storage or a refuse pile. These wastewaters can be high in certain metals concentration, especially after a substantial rainfall event (13). Also, acid waters can be formed in underground mines and aquifers if sufficient air is present to permit oxidation of pyritic materials in either the coal seam or adjacent strata. The leaching process is promoted by a long contact time for water and the sulfur-containing material.

Characteristics of Acid Mine Drainage

The principal pollutants in surface water from mines exhibiting acid mine drainage include suspended and dissolved solids, pH, and certain metal species. Causes for the formation of low pH and high metals concentrations have just been discussed. In general, the problem of acid mine drainage is confined to western Maryland, northern West Virginia, Pennsylvania, Ohio, western Kentucky, and along the Illinois - Indiana border. Acid drainage is not serious in the West because the coals and overburden contain little pyrite and because the amount of infiltration into spoils is low due to low rainfall (14, 15).

Suspended solids result from erosion of scarified areas, where vegetation has been removed. The level of sediment concentration in runoff is a function of the following:

1. Slope of the area
2. Residual vegetation
3. Soil type
4. Surface texture
5. Drainage area
6. Precipitation intensity and duration
7. Existing soil moisture
8. Particle or aggregate size.

The number and interaction of these variables render wide variations in raw wastewater from day to day in any one mine, and from mine to mine in a given region.

Dissolved solids can result from infiltration of precipitation that leaches through spoil and coal piles. Acid leaching of soil and coal, and ion exchange reactions of runoff and soil also cause the formation of this pollutant. Calcium, magnesium, and sodium are the principal dissolved materials in surface runoff.

The factors affecting the quantity of wastewater generated by a surface mine include:

1. Frequency, intensity, and duration of precipitation and snowmelt events
2. The number, porosity and water content of any aquifers above or including the coal seam that are mined through or breached
3. Drainage area
4. Soil porosity
5. Pump capacity and rate
6. Evaporation rate
7. Watershed slope and flow length.

Groundwater is the primary source of drainage from underground mining sites. Underground operations in or below aquifers can cause localized decline of the water table, changes in flow direction and possible changes in flow rate (15). Lowering of water levels may cause wells or springs in the vicinity to dry up. Fracturing as a result of subsidence may similarly alter groundwater flow. In addition, the presence of subsidence fractures and depressions at the surface may increase groundwater recharge in the vicinity of the mine (16).

Underground mining may also cause degradation of groundwater quality. Flow of groundwater through a mine with acid forming potential may result in leaching of soluble materials including trace metals and other ions that will cause an increase in dissolved solids content and may contaminate groundwater supplies.

During the screening phase, facilities 00005, 00012, 00017, 00018, and 00021 through 00024 were sampled. For facility 00012, drainage from inactive mine areas was the source of acid drainage. Verification sampling was conducted at mines 00198, 00021, 00023, 00188 through 00190, and 00197. Descriptions of the above facilities and treatment process schematics, including sampling points, can be found in Appendix F. Engineering site visits were conducted at mines 00035, 00038, and 00195. Data for toxic pollutants, and conventional and nonconventional pollutants in untreated acid mine drainage appear in Table V-5. As can be seen from the table, organics concentrations are very low from these mining operations. In contrast, conventional and toxic metals concentrations are often quite substantial. All raw data are contained in Appendix B.

Alkaline Mine Drainage

The discussion on sediment concentrations and wastewater quantity in the acid mine drainage subsection is also applicable to alkaline mine drainage and will not be repeated here.

Facilities 00001, 00002, 00003, 00004, 00006, 00007, 00011, 00013, 00014, 00015, 00016, 00019, 00020, and 00025 were sampled during the screening phase. During verification sampling, mines 00011, 00018, and 00025 were revisited and mines 00009 and 00010 were sampled for the first time. Mine 00018 is also listed under acid mines during the screening phase because it possesses both acid raw effluents and alkaline raw effluents. These samples were appropriately divided and recorded on the proper table. Descriptions of the above facilities and treatment schematics, including sampling points, can be found in Appendix F.

Mines 00009, 00032, 00033, 00034, 00036, 00037, 00103, 00107, 00193, 00194, and 00196 were sampled during the engineering site visits. EPA Region 8 sampled mines 00029 and 00030. EPA Region 4 sampled facility 00031. Data for toxic pollutants and conventional and nonconventional pollutants from all these sources are summarized in Table V-6. As shown on the table, organics concentrations and metals concentrations are both very low. Further, conventional pollutants with the exception of TSS are very low. The raw data are contained in Appendix B.

Preparation Plants

Wastewater is generated in a coal preparation plant from the coal cleaning process. Flow rates vary widely depending upon certain factors such as the degree of cleaning, the equipment or processes used, and the characteristics of the run-of-mine coal. Each of these factors was discussed in detail in Section IV.

Physical coal cleaning removes impurities from coal via a mechanical separation process. In most cleaning operations, this separation of impurities is based on a specific gravity difference between less dense coal and heavier contaminants such as sulfur, ash, and rock. Sulfur occurs in a coal seam in three forms: as pyrites, in organic compounds, and as sulfate. In coal, the sulfur contribution from sulfate is almost always negligible. The total sulfur content may vary from less than one percent to over eight percent, with most coals in the two to five percent range.

The total sulfur content distribution between the organic and pyritic forms ranges from 5 to 60 percent and 40 to 95 percent, respectively. Organic sulfur in coal is chemically bound and requires a chemical extraction process for removal; physical coal cleaning is restricted to removal of ash, refuse, and the pyritic sulfur (FeS_2) from coal.

In the physical cleaning processes, water is most often used to assist in the removal of unwanted components. The water consumption and usage in a preparation plant was discussed in the previous section. Effluents are most often laden with suspended coal and refuse fines. This slurry is generally dewatered by mechanical or thermal drying equipment internal to the preparation plant, with the water recycled and the partially dewatered, solids-laden slurry discharged to a dewatering and slurry treatment system. Clarified water from this section can often be recycled to the preparation plant to reduce makeup water needs as well as lessen the quantity of final discharge to a receiving stream.

Facilities 00003 through 00005, 00007, 00008, 00011 through 00014, 00017, 00019 through 00022, 00024, and 00025 were sampled during the screening phase of sampling. During verification, preparation plants 00011, 00021 and 00025 were revisited and sampled and facilities 00018 and 00023 were sampled for the first time. Engineering site visits were conducted at preparation plants 00032 through 00035. Analytical results for each of these facilities are summarized on Table V-7, with the raw data in Appendix B. The flow charts and a description for each facility may be found in Appendix F. The high metals concentrations are the result of coal and refuse fines found in a preparation process slurry effluent. The suspended solids levels in some of these slurries can be quite high if no fines recovery or removal is practiced.

Preparation Plant Associated Areas

The principal source of drainage in preparation plant associated areas is precipitation-induced runoff. Three areas generating drainage can be delineated:

1. Coal storage piles
2. Refuse piles
3. Other disturbed areas.

Coal Storage Piles

The quantity and quality of wastewater generated by drainage through a coal storage pile are highly variable, depending upon rainfall conditions, pile configuration, and coal quality and size. The phenomena responsible for the formation of acid mine drainage in the active mining area can also operate within the coal storage pile. The outer layer of a coal pile (to a depth of approximately one foot) is subject to slacking. Slacking refers to rapid changes in moisture content brought about by alternating sun and rain. This often opens up fresh surfaces and accelerates oxidation. Although organic leaching rates are very low, specific inorganic coal components, such as calcium, magnesium, and toxic metals may be contained in the wastewater. Erosion of waste coal fragments can result in high suspended solids levels (18).

Pollutants can be leached into any water contacting the coal storage pile. The composition of pile drainage is influenced by the residence time of the water within the pile. Precipitation will wash this leachate from the pile, so that contaminant concentrations will decrease with increasing water flow rate, until the time that this flushing is complete.

Refuse Piles

Mining, crushing, and washing processes concentrate the coal impurities in the refuse. Extraneous metals and other minerals are separated from the coal and may appear in refuse pile runoff. As most coal-cleaning methods employ gravity separation, dense materials such as clays, shales, and pyrite will be removed as refuse (12). These will contribute to suspended solids levels in the wastewater, while oxidation of the pyrite will produce acid drainage. Organic sulfur and fine pyrite cannot easily be extracted from coal (11), so that these forms do not contribute as significantly to sulfate formation. The relative acidity and pollutants levels of refuse pile drainage are dependent upon the following:

1. Mineral characteristics of the coal and surrounding strata
2. Extent of refuse compaction
3. Configuration of the refuse pile
4. Of soil cover
5. Climatology
6. Surface water control practices

Other Disturbed Areas

Other disturbed areas ancillary to the preparation plant are analogous to those associated with mines, e.g., adjacent haul roads. As is the case for mines, suspended solids is the pollutant of concern in runoff.

Screening samples were collected from associated areas at facilities 00016, 00017, 00018, and 00024. Facility 00018 was resampled during the verification phase. Preparation plant associated areas at facilities 00034, 00038, and 00036 were sampled during the engineering site visits. Descriptions of treatment processes, including sampling points, can be found in Appendix F. A summary of the organic, metal and classical pollutants found during the screening and verification sampling programs appears in Table V-8.

Post Mining Discharges

Reclamation Areas

Reclamation areas are tracts of surface acreage which have been recontoured and seeded to establish ground cover after mining has ceased. Regrading has already been completed by removal of the spoil peaks and reestablishment of natural drainageways. Replanting of indigenous grasses, legumes, and other annual or perrenial flora occurs as soon as possible to stabilize the regraded area. Runoff from this area directly following active mining can exhibit substantial suspended solids loadings until vegetation is well established.

Data from a self-monitoring survey initiated by the Agency are presented in Table V-9. These data are from facilities 00015, 00033, 00037, 00085, 00101, and 00181 through 00187. Also included in Table V-9 are data from facility 00033 sampled during the engineering site visits. As shown on the table, suspended solids loadings are substantial. This is particularly true for rainfall conditions.

Undergound Mines

Discharges from underground mines will continue after the temporary or permanent cessation of mining until appropriate mine closure procedures are implemented. This is because the principal source of water is from aquifers that were intercepted during mine development. These waste-bearing strata will continue to drain water into the mine during and after the production of coal. A study was conducted to characterize these discharges from active and abandoned anthracite underground mines (20). The results of the study indicate that these discharges will be similar to the wastewaters encountered during active mining. For instance, an active discharge and an adjacent abandoned discharge from one mining operation exhibited similar characteristics. The reader is referenced to the active mine drainage tables (Tables

V-5 and V-6) for more detailed characterization of post mining discharges from underground mines.

SUPPORT FOR THE PROPOSED SUBCATEGORIZATION SCHEME

In light of the data characterizing raw wastewater, this subsection will discuss the evolution of the final BPT, BAT, and NSPS subcategorization schemes already presented at the beginning of this section. Preliminary analysis of the results of the BAT screening and verification program (conducted from 1977 to 1979) suggested a number of changes to the BPT categorization. Some of these changes were retained, while others were eliminated based on additional data.

First, surface and underground mines were categorized separately for both acid and alkaline mines. In addition to differences in raw wastewater characteristics, this separation resulted from differences in the type of treatment technology that would be applied at surface and deep mines. For instance, mobile or skid mounted treatment processes are more feasible at surface mines where current treatment facilities (i.e., sedimentation ponds and possibly neutralization equipment) frequently require relocation. At underground facilities, permanent treatment facilities can usually be installed for the life of the mine.

Second, separate subcategories for preparation plants and preparation plant associated areas were established because of the different types of wastewaters discharged by the two areas.

Third, post mining discharges were established as a subcategory to provide regulatory coverage for both surface reclamation areas and underground mine discharges.

Fourth, Pennsylvania anthracite mines were identified as a candidate subcategory based on potential differences in toxic pollutant discharges by different ranks of coal.

Fifth, western mines were separately categorized because of the potential effects of different climatology and coal seams on mine discharges.

These modifications resulted in the following preliminary subcategorization scheme:

1. Acid drainage surface mines
2. Acid drainage underground mines
3. Alkaline drainage surface mines
4. Alkaline drainage underground mines
5. Preparation plants
6. Preparation plant associated areas
7. Post mining discharges

8. Pennsylvania anthracite
9. Western mines

These subcategories were reviewed by consideration of (1) the engineering principles involved, and (2) the data collected from BAT sampling programs conducted after the screening and verification effort. The following discussion presents the results of this review for each subcategory.

Surface and Underground Mines

Two factors were utilized to establish the surface/underground distinction: (1) differences in raw wastewater characteristics and (2) differences in the mobility of applicable treatment options. Both of these are rendered academic, however, because of the reduction achieved by application of existing (BPT) technology. When the untreated discharges from deep and surface are subjected to BPT treatment, the resulting effluent are very similar in "classical" pollutants (TSS, iron, manganese). Tables V-10 and V-11 illustrate these data for alkaline and acid mines. Although substantial differences between deep and surface mines occur for acid and alkaline raw wastewaters, these tables indicate the similarity of BPT-treated discharges with respect to these three key pollutants. The similarity of treated effluent also extends to the toxic metals, as can be seen in Table V-12. Because of these factors, separate subcategories for surface and underground mines were not established.

Preparation Plants and Preparation Plant Associated Areas

These two segments of the coal mining category are classified differently for new sources than for existing sources. For new sources, separate subcategorization of preparation plants and associated areas is based upon differences in the following:

1. TSS and metals concentrations
2. Treatment strategies
3. Water usage requirements
4. Regulatory strategies

First, a comparison of metals and TSS concentrations in these two subcategories is presented in Table V-10. It is seen that preparation plant process effluent is much higher in suspended solids, while toxic metals occur more consistently and in higher concentrations than in associated areas runoff. It is not merely the differences in water quality as apparent from the data, but the differences in treatment strategy implied by these data, that support this division. The major contributor to total metals in the preparation plant slurry is suspended metals, due to the nature of the cleaning process. This is evidenced by the data in Table V-14. This indicates that settling of preparation plant slurry will provide substantial removal of toxic metals. Conversely, metals from associated areas are mostly due to the low pH, and thus a different treatment strategy would be selected, i.e., pH adjustment via neutralization.

Figure V-2 shows two typical preparation plant water circuits. Although many factors suggest different treatment systems for preparation plants and associated areas, most facilities commingle these drainages, as illustrated in the top configuration of Figure V-2. For new sources, segregated treatment can be designed into the overall wastewater system. The incentives for separate treatment are discussed below.

Water management considerations and economics will most often dictate maximizing water recycle. Preparation plants utilize water to assist in cleaning the coal, and thus the water is process water subject to one class of treatment options. Runoff from associated areas is usually not used in coal cleaning, and hence different wastewater treatment strategies are suggested. For instance, the intermittent runoff generated in associated areas is suited to a sedimentation pond system with possible neutralization required if this runoff is acidic. On the other hand, a preparation plant continually discharges process wastewater from the coal cleaning equipment while the plant is operating. This continuous effluent is usually alkaline and solids-laden and is thus suited for a settling and decant recycle system. Slurry impoundments could also be used; the flow to these would not increase during a rainfall unless surface runoff is also received. This is not the case for associated areas which most often only discharge significant quantities during rainfall events. Finally, increased regulatory flexibility is provided by separating these as subcategories. This is particularly in reference to the potential for a "zero discharge" or total recycle regulation for preparation plant slurry waters. If the associated area runoff can be segregated from slurry effluent, the water balance can be achieved through diversion ditching and other techniques, thus allowing total water recycle systems for preparation plants. This is more extensively discussed in Sections VII and VIII.

For existing sources, however, these reasons are overridden by consideration of engineering and cost factors. Current practice in the industry is commonly to commingle wastewater from refuse and storage piles (associated areas) with preparation plant process wastewater for treatment. To set differing limitations for the two segments would cause most operators to segregate the two types of drainage, which would require massive expenditures and gross inefficiency for a facility. Installation of extensive retrofit equipment and construction of new ponds would severely impact the capital and human resources of many coal mining operations. For existing sources this commitment of resources would happen with little environmental improvement. A further discussion of these factors is presented in Section VII.

Pennsylvania Anthracite Mines

The Agency examined anthracite mining and preparation to assess any statistical or technical differences in wastewater from bituminous and lignite operations. Results shown in Table V-15 indicate that no significant differences exist; thus anthracite facilities will be categorized identically with bituminous and lignite operations.

Post Mining Discharges

Surface and underground mines can continue to discharge polluted wastewater after production from the mine has ceased. For surface mines, this discharge consists of runoff from a previously mined area that has been backfilled, regraded, and revegetated. This process, called reclamation, is an ongoing operation at one area of a mine that occurs simultaneously with active mining of another area. For underground mines, the post-mining discharge results from groundwater infiltration into the mined out areas. This groundwater can originate from breached aquifers or from adjacent abandoned mines. During active mining, water is usually pumped to the surface for treatment and discharge. After mine closure, this water will continue to drain into the mine workings. Over a priod of time, several outcomes are possible. First, a state of equilibrium could occur when the gravity head of the water balances the infiltration pressure. Second, the water could erode and break through mine seals to adjacent active or abandoned mine tunnels. Third, the mine pool could continue to rise until the level reaches ground level, and, should no mine seal be in place, a surface discharge occurs. Fourth, if the mine is sealed, the water can erode and break through the seal, again resulting in a surface discharge.

The post-mining discharges from either a reclamation area at a surface mine or from an abandoned underground mine can contain significant amounts of pollutants. These wastewaters were not previously regulated by EPA, and so were postulated as a candidate subcategory for BAT and NSPS effluent limitations. To verify this for the final subcategorization, data were gathered from four independent studies. A self monitoring industry survey was initiated at 24 surface mine sites to characterize raw and treated streams from reclamation areas. These data are presented in Table V-9. A second and more exhaustive study is being conducted at eight surface mine sites with the same purpose. Data are not yet available from this study. To collect data on post-mining discharges from underground mines, four anthracite mines were sampled. Among the wastewaters sampled were discharges from underground abandoned mines. The data are contained in a supplement to this report (20), and were also presented in Table V-15. Finally, a data collection program at several abandoned mines is currently being conducted. No data are yet available from this effort. Results from programs where data have been available indicate that drainage from surface mines under reclamation contains suspended solids as the only pollutant of concern. Concentrations for iron, manganese, and the toxic metals were lower than typical values from active mine drainage. On the other hand, post-mining discharges from underground mines are very similar to wastewater generated during active mining. This is because the mechanism for wastewater generation is identical. Nevertheless, these discharges are subcategorized separately from active mine drainage because these discharges were not covered under BPT regulations.

Western Mines

An evaluation of the nature of discharges from western mines has been performed to determine the appropriateness of separately subcategorizing mines in this region. Coal mines west of the 100th meridian in the United States have been designated western mines (42 FR 46937, 19 September 1977). This includes mines in Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming (42 FR 21380, 26 April 1977). These coal regions are depicted in Figure V-3.

This candidate subcategory was established to recognize potential differences in achievable effluent quality between eastern and western mines for a number of reasons.

First, the West receives substantially less rainfall than the eastern region. Further, evaporation rates are higher primarily because of the lower humidity in the West. These two conditions result in a lesser amount of runoff and high evaporation from settling ponds, also termed "positive evapotranspiration." Figure V-4 illustrates the location of these positive evapotranspiration areas. Finally, site-specific conditions such as topography and hydrogeology are potential incentives for separation regulations.

Tables V-16 through V-19 present data from the BAT sampling program for eastern and western raw wastewaters. Treated effluent data for the two regions appear in Tables V-20 through V-23. Additional data from discharge monitoring reports (DMRs) are summarized in Table V-24. Information collected from the DMRs indicates that western mines (16 facilities were included) exhibit no discharge 41 percent of the time samples were taken (or attempted to be taken). The comparable figure from eastern mines (56 facilities were included) is 19 percent. However, as Tables V-20 through V-23 indicate, the final discharge compositions are very similar for eastern and western mines when a discharge did occur.

This is further verified by a statistical analysis. The purpose of this analysis was to determine, with respect to TSS, whether effluent discharges at Western alkaline mines were statistically different from effluent discharges at Eastern alkaline mines. The data available for the analysis consisted of 68 samples from Eastern mines (22 influent and 46 effluent) and 26 samples from Western mines (11 influent and 15 effluent).

The statistical approach used was a "goodness of fit" test. This was adopted because of the limited number of samples available from Western mines. Under this approach, the more plentiful Eastern mine data is used to define a sample distribution for TSS. A statistical test is then performed to determine how well the Western mine data "fit" into the Eastern mine distribution. The test results show that the distribution of TSS at Western mines is statistically similar to that at Eastern mines.

Figure V-5 provides observed and expected frequencies for influent and effluent samples at Western mines. The expected frequencies are those which one would expect to see if the Western mine data followed the same distribution as the Eastern mine data. The observed frequencies are those which were actually found in the data. These frequencies were calculated by classifiying each value of TSS observed at a Western mine into one of the four quadrants of the TSS distribution established for Eastern mines. The quandrants of a distribution are those areas which divide the data into four equally dense portions. That is, the first quadrant will contain 25 percent of the data, the second quadrant will contain 25 percent of the data and so on. It should be noted that quadrants were established independently for influent and effluent samples. The expected frequencies are found by taking 25 percent of the available samples. Since there were 11 influent samples, one would expect approximately three to fall into each quadrant if the distribution of TSS at Western mines was similar to that at Eastern mines.

Figure V-5 shows that in most cases the observed frequencies are similar to the expected frequencies. The largest differences are found in the second and fourth quadrants of the influent distribution. Calculation of a chi square statistic indicates that these differences are not statistically significant.

Based on these facts, a separate subcategory for western mines is not warranted.

Figure VIII-30

SYSTEM 2 - NEW SOURCE WATER CIRCUITS

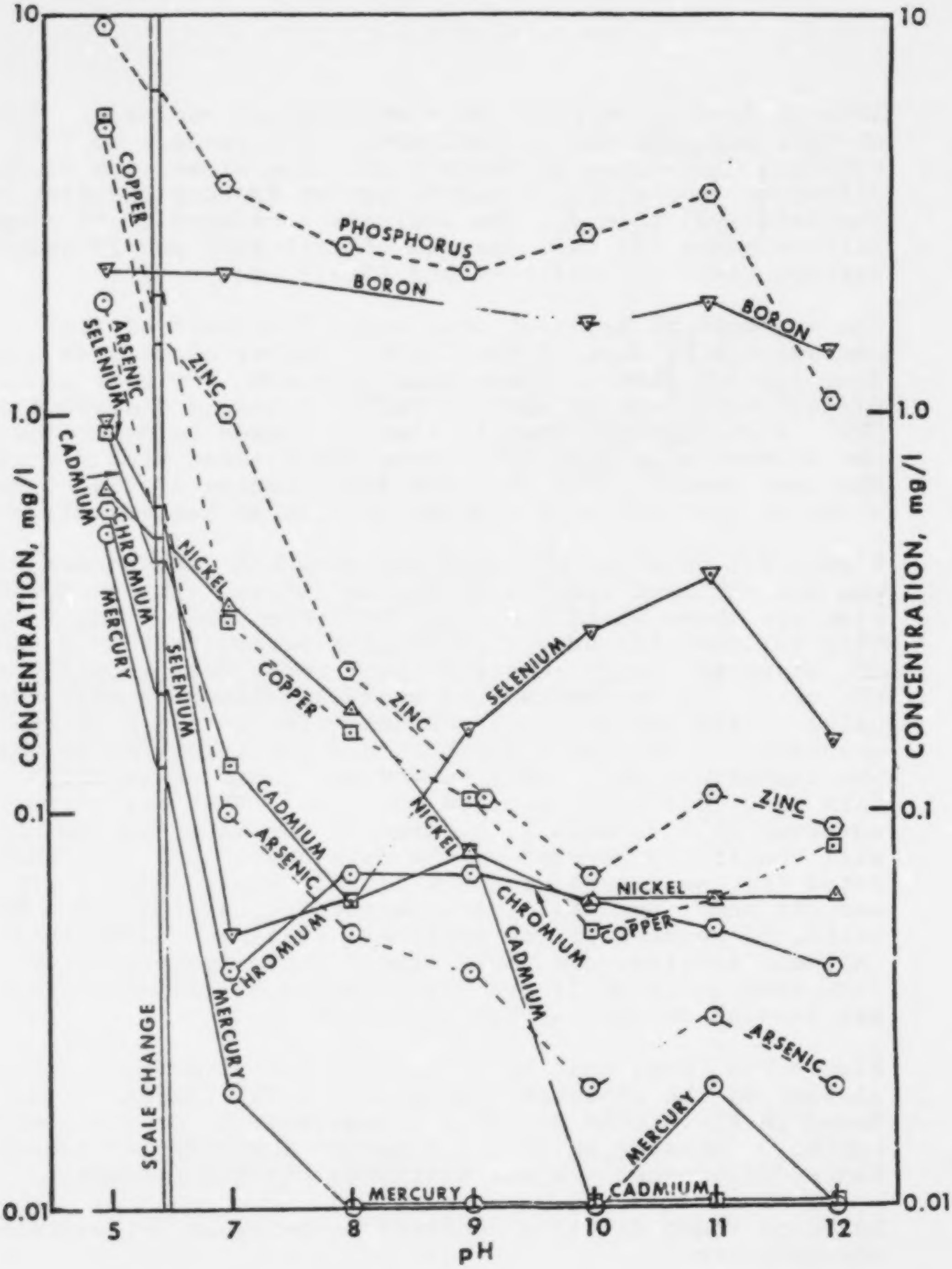

Figure V-1
CONCENTRATIONS OF CERTAIN ELEMENTS AS A FUNCTION OF pH

Source: (7)

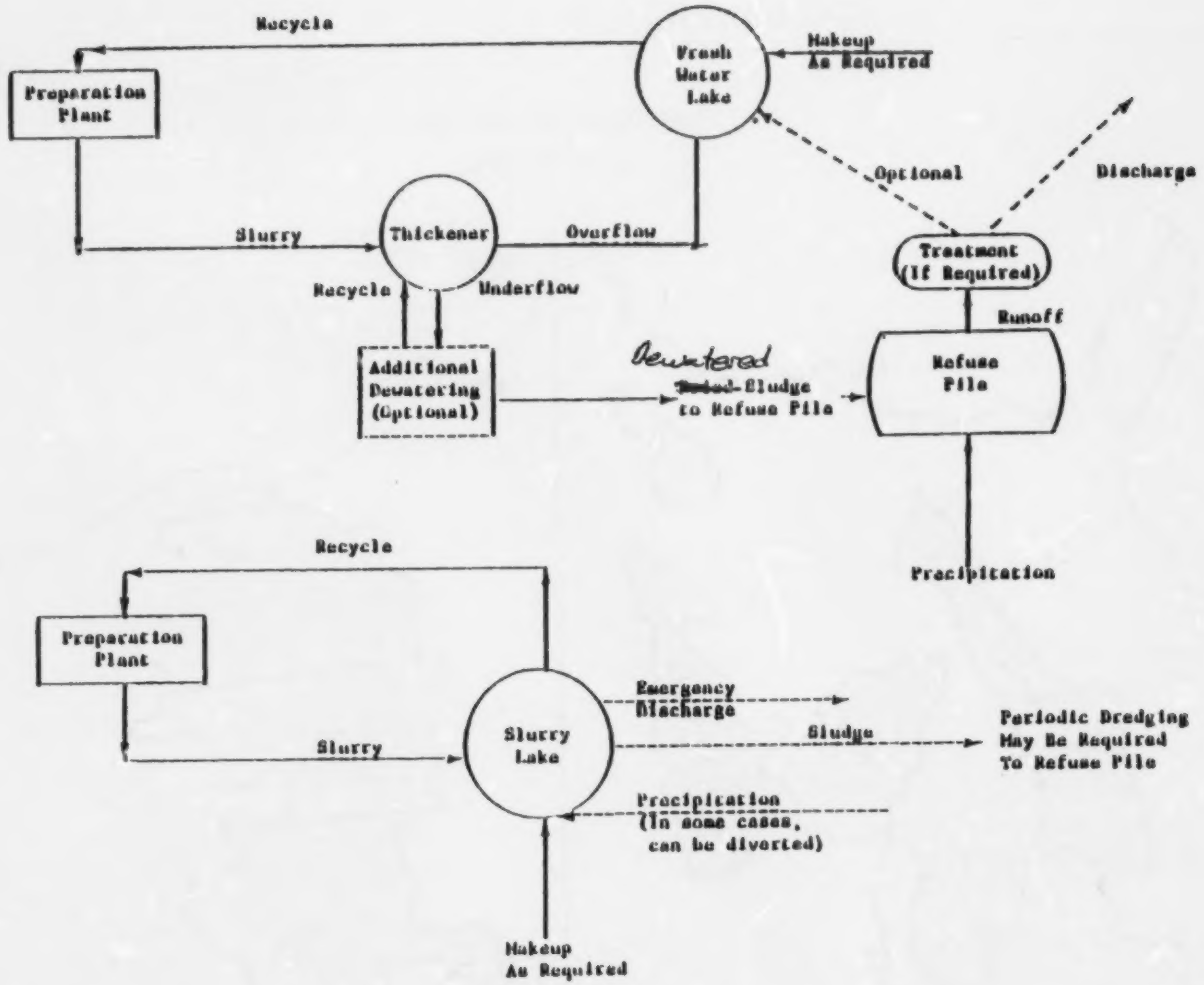
Recycle
Preparation Plant
Fresh Water Lake
Makeup As Required
Optional
Discharge
Slurry
Thickener
Overflow
Treatment (If Required)
Recycle
Underflow
Runoff
Additional Dewatering (Optional)
Dewatered
~~Total~~ Sludge to Refuse Pile
Refuse Pile
Precipitation
Recycle
Preparation Plant
Emergency Discharge
Slurry
Slurry Lake
Sludge
Periodic Dredging May Be Required To Refuse Pile
Precipitation (In some cases, can be diverted)
Makeup As Required

Figure V-2

TYPICAL PREPARATION PLANT WATER CIRCUITS

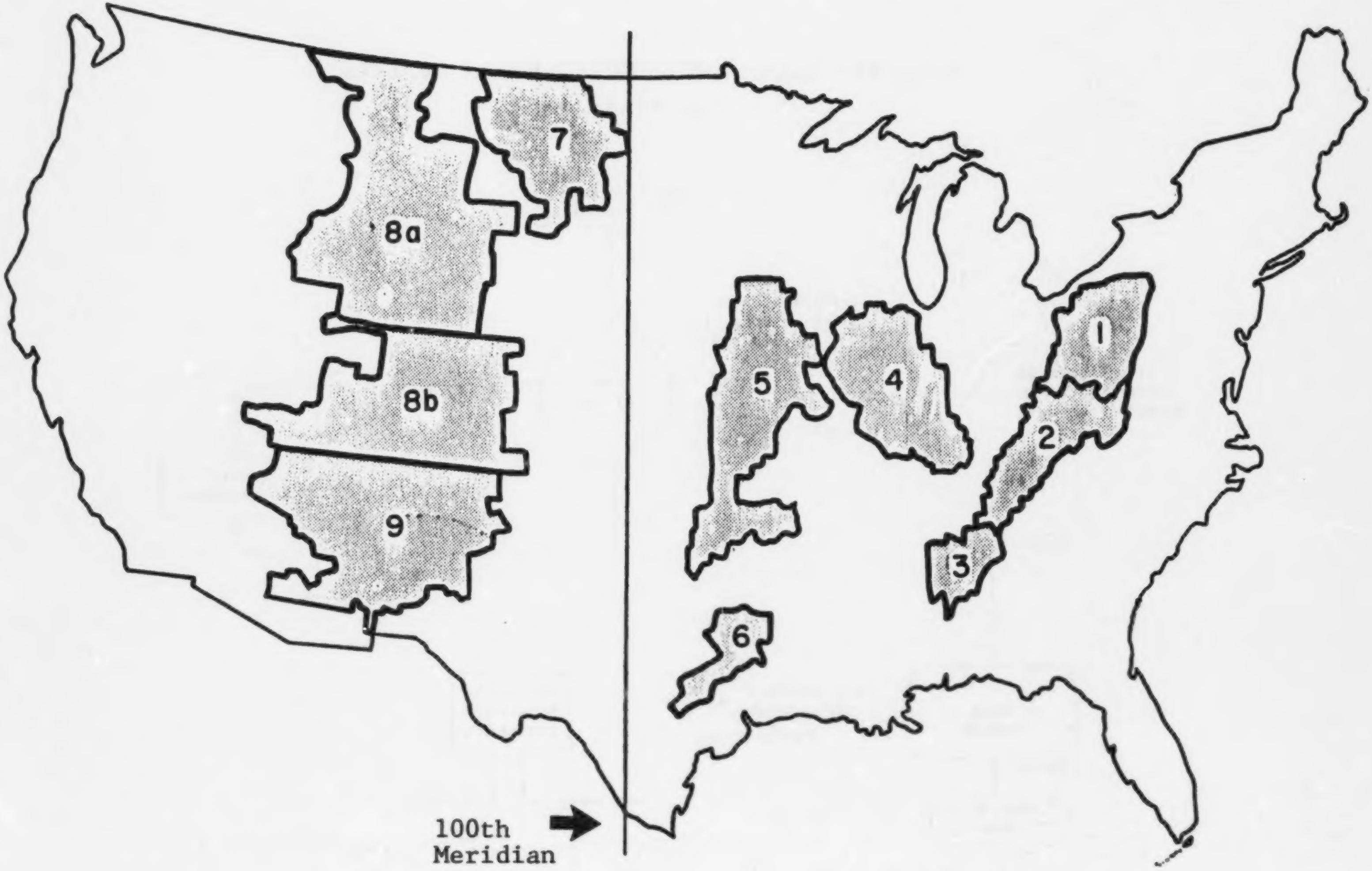
1
2
3
4
5
6
7
8a
8b
9
100th
Meridian

Figure V-3
COAL MINING REGIONS

Source: (10)

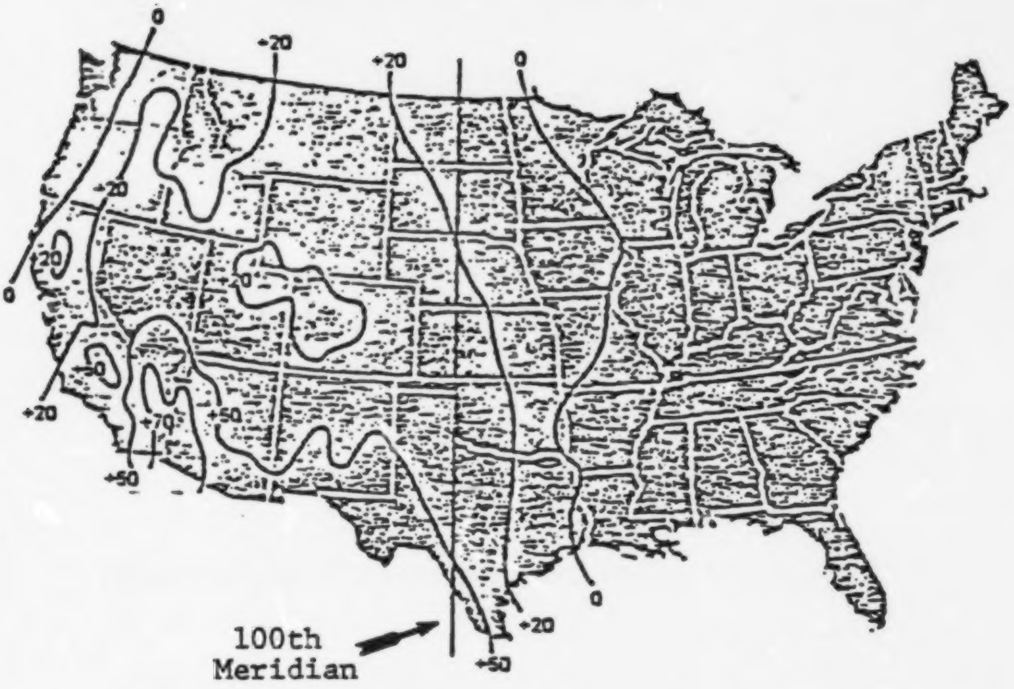
0
+20
+20
0
+20
+20
0
0
+50
+20
+70
+50
+50
0
+20
+50
100th Meridian

Figure V-4

RELATION OF AREAS OF POSITIVE EVAPOTRANSPIRATION
TO THE 100th MERIDIAN

Figure V-5

OBSERVED AND EXPECTED FREQUENCIES AT WESTERN ALKALINE MINES

	QUADRANTS				
	1	2	3	4	
Influent	3 (3)	0 (2)	3 (3)	5 (3)	11
Effluent	4 (4)	5 (4)	3 (4)	3 (3)	15
	7	5	6	8	26

Expected frequencies are given in parentheses.

Table V-1

DATA SOURCES DEVELOPED DURING BAT REVIEW FOR WASTEWATER CHARACTERIZATION

Number of Facilities by Proposed Subcategory

Data Source	Acid	Alkaline	Preparation Plants	Preparation Plant Associated Areas	Reclamation Areas
Screening	9	14	15	6	0
Verification	7	5	5	2	0
Engineering Site Visits	3	11	5	4	1
EPA Regional Studies	0	3	1	0	0
Self-Monitoring Survey	0	0	0	0	24
Prep. Plant Questionnaire	0	0	152	152	0
Prep. Plant Sampling	0	0	3	3	0
NPDES DMR	56	32	12	1	0
Site Specific Areas Under Reclamation	0	0	0	0	8
TOTALS	75	65	193	168	33

Table V-2

DATA BASE SOURCES

	Type of Facility	
	Anthracite, Bituminous Coal and Lignite Mines	Preparation Plants and Associated Areas
BPT Study	89	34
BCRI Surveys	162	118
*BAT Screening and Verification	29	19
*Self-Monitoring Survey	17	0
*EPA Region IV, VIII	3	1
*Engineering Site Visits	14	8
*Preparation Plant Site Visits	0	3
*Preparation Plant Industry Survey	0	152
Total No. in Data Base	314	335
Total No. of Independent Facilities in Computerized Data Base	58	167
Percent of 1978 Total Production Represented in Total Data Base	39	43

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*Data from this source has been computerized.

Table V-3

TREATABILITY STUDIES CONDUCTED ON COAL MINE DRAINAGE

Technology Examined	Site(s) of Study or Mine(s)	Type of Drainage Treated	Dates of Effort	Reference
Lime/Limestone	Crown, WV	Acid Mine Drainage (Ferrous Iron)	1974-1976	(1)
Lime/Limestone	Norton, WV	Acid Mine Drainage (Ferric Iron)	1974	(2)
Reverse Osmosis	Norton, WV Morgantown, WV Ebensburg, PA Mocanaqua, PA	Acid Mine Drainage	1972	(3)
Flocculant Addition	Norton, WV Hollywood, PA Crown, WV Stonefort, IL	Acid Mine Drainage	1979	(4)
Granular Media Filtration	Ebensburg, PA Greensboro, PA	Acid Mine Drainage Acid Mine Drainage	1980	(5)
Neutralization Aeration Ozonation Sand Filtration Carbon Adsorption	Crown, WV	Acid, Alkaline Mine Drainage for Organics and Toxic Metals	1978-1979	(6)
Reverse Osmosis Ion Exchange Lime Neutralization	Crown, WV	Acid Mine Drainage	1978	(7)

Table V-4

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	49	3	0	3	*	3	3	*	3
ACROLEIN	47	0	0	.	*	.	.	*	.
ACRYLONITRILE	47	0	0	.	*	.	.	*	.
BENZENE	47	13	8	2	2	16	24	47	73
BENZIDENE	49	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	47	0	0	.	*	.	.	*	.
CHLOROBENZENE	46	1	1	12	*	12	12	*	12
1,2,3-TRICHLOROBENZENE	49	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	49	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	47	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	47	4	1	3	*	3	8	*	23
HEXACHLOROETHANE	49	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	47	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	47	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	47	0	0	.	*	.	.	*	.
CHLOROETHANE	47	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	47	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	49	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	47	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	49	1	0	3	*	3	3	*	3
2,4,6-TRICHLOROPHENOL	46	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	46	0	0	.	*	.	.	*	.
CHLOROFORM	47	25	22	3	8	32	95	306	476
2-CHLOROPHENOL	46	1	1	86	*	86	86	*	86
1,2-DICHLOROBENZENE	49	2	1	3	*	3	11	*	18
1,3-DICHLOROBENZENE	49	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	49	1	0	3	*	3	3	*	3
3,3-DICHLOROBENZIDINE	48	0	0	.	*	.	.	*	.

Table V-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	47	3	0	3	*	3	3	*	3
1,2-TRANS-DICHLOROETHYLENE	47	1	0	10	*	10	10	*	10
2,4-DICHLOROPHENOL	46	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	47	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	47	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	46	3	3	18	*	20	21	*	24
2,4-DINITROTOLUENE	49	1	1	18	*	18	18	*	18
2,6-DINITROTOLUENE	49	1	1	30	*	30	30	*	30
1,2-DIPHENYLHYDRAZINE	49	1	0	3	*	3	3	*	3
ETHYLBENZENE	48	4	1	2	*	3	5	*	11
FLUORANTHENE	49	5	2	3	*	3	6	*	11
4-CHLOROPHENYL PHENYL ETHER	49	1	0	3	*	3	3	*	3
4-BROMOPHENYL PHENYL ETHER	49	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	49	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	49	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	47	43	34	3	3	501	1186	2201	11190
METHYL CHLORIDE	47	0	0	.	*	.	.	*	.
METHYL BROMIDE	47	0	0	.	*	.	.	*	.
BROMOFORM	47	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	47	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	47	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	47	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	47	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	49	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	49	0	0	.	*	.	.	*	.
ISOPHORONE	49	1	1	307	*	307	307	*	307
NAPHTHALENE	49	10	6	2	2	10	75	220	410
NITROBENZENE	49	1	1	21	*	21	21	*	21

Table V-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	46	1	1	17	*	17	17	*	17
4-NITROPHENOL	46	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	46	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	46	1	1	194	*	194	194	*	194
N-NITROSODIMETHYLAMINE	49	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	49	1	1	45	*	45	45	*	45
N-NITROSODI-N-PROPYLAMINE	49	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	46	0	0	.	*	.	.	*	.
PHENOL	46	6	1	3	*	3	5	*	16
BIS(2-ETHYLHEXYL) PHTHALATE	49	21	12	3	3	9	16	44	62
BUTYL BENZYL PHTHALATE	49	4	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	49	19	3	2	3	3	4	6	11
DI-N-OCTYL PHTHALATE	49	1	0	3	*	3	3	*	3
DIETHYL PHTHALATE	49	11	1	1	1	3	5	3	23
DIMETHYL PHTHALATE	49	1	0	3	*	3	3	*	3
BENZO(A)ANTHRACENE	46	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	49	7	2	1	*	3	24	*	141
BENZO(B)FLUORANTHENE	49	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	49	3	2	1	*	4	6	*	11
CHRYSENE	46	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	49	1	1	9	*	9	9	*	9
ANTHRACENE	46	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	49	7	1	1	*	3	5	*	10
FLUORENE	49	5	2	1	*	3	14	*	44
PHENANTHRENE	46	1	1	12	*	12	12	*	12
DIBENZO(A,H)ANTHRACENE	49	5	0	3	*	3	5	*	10
INDENO(1,2,3-C,D)PYRENE	49	4	0	3	*	3	6	*	10
PYRENE	49	6	2	1	*	3	9	*	25

Table V-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	47	0	0	.	*	.	.	*	.
TOLUENE	47	18	10	2	2	11	18	40	45
TRICHLOROETHYLENE	47	1	0	3	*	3	3	*	3
VINYL CHLORIDE	47	0	0	.	*	.	.	*	.
ALDRIN	45	1	0	6.40	*	6.40	6.40	*	6.40
DIELDRIN	45	3	0	2.24	*	2.24	2.28	*	2.30
CHLORDANE	46	0	0	.	*	.	.	*	.
4,4-DDT	45	0	0	.	*	.	.	*	.
4,4-DDE	45	1	0	2.24	*	2.24	2.24	*	2.24
4,4-DDD	45	1	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN-ALPHA	45	3	0	0.10	*	1.17	1.52	*	2.24
ENDOSULFAN-BETA	45	2	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN SULFATE	46	0	0	.	*	.	.	*	.
ENDRIN	46	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	45	2	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR	45	2	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR EPOXIDE	45	3	0	0.20	*	1.22	1.58	*	2.24
BHC-ALPHA	45	5	0	1.10	*	2.24	2.08	*	2.24
BHC-BETA	45	6	0	0.33	*	1.40	1.47	*	2.60
BHC (LINDANE)-GAMMA	45	5	0	0.43	*	2.24	1.87	*	2.24
BHC-DELTA	45	5	0	0.10	*	1.23	1.41	*	2.24
PCB-1242 (AROCHLOR 1242)	46	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	46	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	46	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	46	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	46	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	46	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	46	0	0	.	*	.	.	*	.

Table V-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	46	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	49	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	45	10	5	2	2	3	24	48	104
BENZO(A)ANTHRACENE/CHRYSENE	19	6	2	1	*	3	15	*	49
BENZO(3,4/K)FLUORANTHENE	16	3	1	3	*	3	4	*	7
ANTIMONY (TOTAL)	103	45	22	1	2	7	40	117	235
ARSENIC (TOTAL)	104	49	28	2	2	38	345	863	6500
BERYLLIUM (TOTAL)	104	32	17	0	1	10	39	92	450
CADMIUM (TOTAL)	104	24	22	6	10	17	42	92	290
CHROMIUM (TOTAL)	104	64	58	6	10	50	288	508	7500
COPPER (TOTAL)	104	75	58	4	6	20	429	1145	6500
CYANIDE (TOTAL)	57	3	0	2	*	4	6	*	8
LEAD (TOTAL)	104	41	32	2	3	67	491	1000	5500
MERCURY (TOTAL)	104	44	8	0.20	0.33	1.10	4.99	14.20	43.00
NICKEL (TOTAL)	104	51	51	23	40	153	729	1210	10000
SELENIUM (TOTAL)	104	39	23	1	3	22	66	213	450
SILVER (TOTAL)	104	32	20	4	5	13	18	31	64
THALLIUM (TOTAL)	104	27	12	1	1	9	26	66	184
ZINC (TOTAL)	104	91	88	7	15	99	1408	2897	30000

Table V-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	98	97	500	2570	57500	1016E4	1460E4	2400E5
PH (UNITS)	100	100	2.4	3.6	7.5	6.9	8.2	9.4
IRON (TOTAL)	105	104	11	209	2230	257576	687997	9000E3
MANGANESE (TOTAL)	103	94	3	25	1075	5190	12600	80000
ASBESTOS(TOTAL-FIBERS/LITER)	10	9	3500E3	*	1090E6	9372E6	*	4100E7
COD	57	52	40	8180	34000	1009E4	3094E4	2220E5
DISSOLVED SOLIDS	38	38	71000	145000	730000	1130E3	2580E3	3200E3
TOTAL VOLATILE SOLIDS	42	41	10000	43400	222167	6968E3	2494E4	8051E4
VOLATILE SUSPENDED SOLIDS	28	22	1000	1080	4600	1418E3	751992	2800E4
SETTLEABLE SOLIDS	65	53	0.0	0.0	0.7	126.6	378.7	1800.0
TOTAL ORGANIC CARBON	56	49	260	1258	14150	1322E3	3022E3	2847E4
FREE ACIDITY (CACO3)	6	6	19000	*	41000	181500	*	740000
MO ALKALINITY (CACO3)	33	33	10	7967	190000	392425	587000	5400E3
PHENOLICS(4AAP)	56	11	2	2	20	33	50	155
SULFATE	8	8	130000	*	503333	659583	*	1530E3
TOTAL ACIDITY (CACO3)	1	1	10500	*	10500	10500	*	10500
TOTAL SOLIDS	35	35	180000	314850	1326E3	9689E3	1180E4	1900E5

Table V-5

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	17	0	0	.	*	.	.	*	.
ACROLEIN	16	0	0	.	*	.	.	*	.
ACRYLONITRILE	16	0	0	.	*	.	.	*	.
BENZENE	16	6	4	2	*	16	20	*	40
BENZIDENE	17	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	16	0	0	.	*	.	.	*	.
CHLOROBENZENE	18	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	17	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	17	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	18	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	16	0	0	.	*	.	.	*	.
HEXACHLOROETHANE	17	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	16	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	18	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	18	0	0	.	*	.	.	*	.
CHLOROETHANE	16	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	16	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	17	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	18	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	17	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	14	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	14	0	0	.	*	.	.	*	.
CHLOROFORM	16	9	9	16	*	34	101	*	442
2-CHLOROPHENOL	14	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	17	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	17	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	17	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	18	0	0	.	*	.	.	*	.

Table V-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	16	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	16	1	0	10	*	10	10	*	10
2,4-DICHLOROPHENOL	14	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	16	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	16	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	14	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	17	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	17	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	17	0	0	.	*	.	.	*	.
ETHYLBENZENE	17	2	0	2	*	2	3	*	4
FLUORANTHENE	17	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	17	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	17	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	17	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	17	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	16	16	15	7	10	487	1596	3804	11190
METHYL CHLORIDE	16	0	0	.	*	.	.	*	.
METHYL BROMIDE	16	0	0	.	*	.	.	*	.
BROMOFORM	16	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	16	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	16	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	16	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	16	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	17	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	17	0	0	.	*	.	.	*	.
ISOPHORONE	17	0	0	.	*	.	.	*	.
NAPHTHALENE	17	3	1	2	*	4	6	*	10
NITROBENZENE	17	0	0	.	*	.	.	*	.

Table V-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	14	0	0	.	*	.	.	*	.
4-NITROPHENOL	14	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	14	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	14	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	17	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	17	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	17	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	14	0	0	.	*	.	.	*	.
PHENOL	14	0	0	.	*	.	.	*	.
BIS(2-ETHYLHEXYL) PHTHALATE	17	10	8	3	3	10	21	46	62
BUTYL BENZYL PHTHALATE	17	0	0	.	*	.	.	*	.
DI-N-BUTYL PHTHALATE	17	8	3	2	*	3	5	*	11
DI-N-OCTYL PHTHALATE	17	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	17	5	1	1	*	2	6	*	23
DIMETHYL PHTHALATE	17	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	14	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	17	3	0	1	*	1	1	*	2
BENZO(B)FLUORANTHENE	17	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	17	3	2	1	*	4	6	*	11
CHRYSENE	14	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	17	0	0	.	*	.	.	*	.
ANTHRACENE	14	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	17	3	0	1	*	4	6	*	10
FLUORENE	17	1	0	1	*	1	1	*	1
PHENANTHRENE	14	1	1	12	*	12	12	*	12
DIBENZO(A,H)ANTHRACENE	17	2	0	6	*	6	8	*	10
INDENO(1,2,3-C,D)PYRENE	17	2	0	7	*	7	8	*	10
PYRENE	17	1	0	1	*	1	1	*	1

Table V-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	16	0	0	.	*	.	.	*	.
TOLUENE	16	7	4	2	*	10	15	*	45
TRICHLOROETHYLENE	16	0	0	.	*	.	.	*	.
VINYL CHLORIDE	16	0	0	.	*	.	.	*	.
ALDRIN	14	0	0	.	*	.	.	*	.
DIELDRIN	14	0	0	.	*	.	.	*	.
CHLORDANE	14	0	0	.	*	.	.	*	.
4,4-DDT	14	0	0	.	*	.	.	*	.
4,4-DDE	14	0	0	.	*	.	.	*	.
4,4-DDD	14	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	14	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	14	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	14	0	0	.	*	.	.	*	.
ENDRIN	14	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	14	0	0	.	*	.	.	*	.
HEPTACHLOR	14	1	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR EPOXIDE	14	0	0	.	*	.	.	*	.
BHC-ALPHA	14	1	0	2.24	*	2.24	2.24	*	2.24
BHC-BETA	14	1	0	2.24	*	2.24	2.24	*	2.24
BHC (LINDANE)-GAMMA	14	0	0	.	*	.	.	*	.
BHC-DELTA	14	1	0	2.24	*	2.24	2.24	*	2.24
PCB-1242 (AROCHLOR 1242)	14	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	14	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	14	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	14	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	14	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	14	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	14	0	0	.	*	.	.	*	.

Table V-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	14	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	17	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	14	3	2	2	*	8	15	*	28
BENZO(A)ANTHRACENE/CHRYSENE	5	1	0	1	*	1	1	*	1
BENZO(3,4/K)FLUORANTHENE	2	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	22	9	1	1	*	2	5	*	26
ARSENIC (TOTAL)	23	13	8	2	2	23	89	169	510
BERYLLIUM (TOTAL)	23	7	4	7	*	12	18	*	34
CADMIUM (TOTAL)	23	3	2	10	*	11	40	*	98
CHROMIUM (TOTAL)	23	11	11	14	14	47	126	177	780
COPPER (TOTAL)	23	17	15	5	7	29	133	174	1290
CYANIDE (TOTAL)	18	0	0	.	*	.	.	*	.
LEAD (TOTAL)	23	6	5	8	*	27	147	*	405
MERCURY (TOTAL)	23	12	0	0.40	0.48	1.30	1.73	3.14	4.10
NICKEL (TOTAL)	23	13	13	23	28	125	469	1000	2020
SELENIUM (TOTAL)	23	12	7	2	2	17	25	55	59
SILVER (TOTAL)	23	10	7	4	4	11	14	29	31
THALLIUM (TOTAL)	23	7	2	1	*	1	4	*	14
ZINC (TOTAL)	23	21	21	11	29	420	932	2209	6620

Table V-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	23	22	9800	11040	65000	1033E4	2984E3	2180E5
PH (UNITS)	25	25	2.5	3.2	5.9	5.6	7.9	8.6
IRON (TOTAL)	23	23	77	588	12367	198222	217500	2790E3
MANGANESE (TOTAL)	23	22	22	283	4300	8323	12400	63000
ASBESTOS(TOTAL-FIBERS/LITER)	2	1	3500E3	*	3500E3	3500E3	*	3500E3
COD	18	15	5100	9050	43150	6027E3	919999	8800E4
DISSOLVED SOLIDS	14	14	71000	71800	450000	655762	1537E3	2130E3
TOTAL VOLATILE SOLIDS	11	11	30000	31200	320250	512818	1252E3	1400E3
VOLATILE SUSPENDED SOLIDS	7	6	1400	*	4000	153100	*	890000
SETTLEABLE SOLIDS	13	9	0.0	*	1.0	70.8	*	600.0
TOTAL ORGANIC CARBON	18	17	260	430	9150	289821	169200	4410E3
FREE ACIDITY (CACO3)	5	5	19000	*	34500	69800	*	180000
MO ALKALINITY (CACO3)	9	9	10	*	39000	54890	*	120000
PHENOLICS(4AAP)	18	1	8	*	8	8	*	8
SULFATE	7	7	130000	*	578333	709524	*	1530E3
TOTAL SOLIDS	11	11	370000	376000	3600E3	3739E3	6740E3	8200E3

Table V-6

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	21	0	0	.	*	.	.	*	.
ACROLEIN	20	0	0	.	*	.	.	*	.
ACRYLONITRILE	20	0	0	.	*	.	.	*	.
BENZENE	20	3	1	3	*	3	26	*	73
BENZIDENE	21	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	20	0	0	.	*	.	.	*	.
CHLOROBENZENE	19	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	21	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	21	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	20	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	20	2	0	3	*	3	3	*	3
HEXACHLOROETHANE	21	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	20	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	20	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	20	0	0	.	*	.	.	*	.
CHLOROETHANE	20	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	20	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	21	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	20	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	21	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	21	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	21	0	0	.	*	.	.	*	.
CHLOROFORM	20	12	10	3	5	32	75	126	468
2-CHLOROPHENOL	21	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	21	2	1	3	*	3	11	*	18
1,3-DICHLOROBENZENE	21	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	21	1	0	3	*	3	3	*	3
3,3-DICHLOROBENZIDINE	21	0	0	.	*	.	.	*	.

Table V-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	20	3	0	3	*	3	3	*	3
1,2-TRANS-DICHLOROETHYLENE	20	0	0	.	*	.	.	*	.
2,4-DICHLOROPHENOL	21	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	20	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	20	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	21	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	21	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	21	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	21	0	0	.	*	.	.	*	.
ETHYLBENZENE	20	1	1	11	*	11	11	*	11
FLUORANTHENE	21	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	21	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	21	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	21	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	21	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	20	19	13	3	3	533	1152	2453	8964
METHYL CHLORIDE	20	0	0	.	*	.	.	*	.
METHYL BROMIDE	20	0	0	.	*	.	.	*	.
BROMOFORM	20	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	20	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	20	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	20	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	20	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	21	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	21	0	0	.	*	.	.	*	.
ISOPHORONE	21	0	0	.	*	.	.	*	.
NAPHTHALENE	21	1	1	11	*	11	11	*	11
NITROBENZENE	21	0	0	.	*	.	.	*	.

Table V-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	21	0	0	.	*	.	.	*	.
4-NITROPHENOL	21	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	21	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	21	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	21	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	21	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	21	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	21	0	0	.	*	.	.	*	.
PHENOL	21	2	0	3	*	3	3	*	3
BIS(2-ETHYLHEXYL) PHTHALATE	21	4	1	3	*	3	6	*	14
BUTYL BENZYL PHTHALATE	21	1	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	21	6	0	3	*	3	3	*	3
DI-N-OCTYL PHTHALATE	21	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	21	2	0	3	*	3	3	*	3
DIMETHYL PHTHALATE	21	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	21	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	21	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	21	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	21	0	0	.	*	.	.	*	.
CHRYSENE	21	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	21	0	0	.	*	.	.	*	.
ANTHRACENE	21	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	21	1	0	3	*	3	3	*	3
FLUORENE	21	0	0	.	*	.	.	*	.
PHENANTHRENE	21	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	21	1	0	3	*	3	3	*	3
INDENO(1,2,3-C,D)PYRENE	21	1	0	3	*	3	3	*	3
PYRENE	21	0	0	.	*	.	.	*	.

Table V-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	20	0	0	.	*	.	.	*	.
TOLUENE	20	3	3	11	*	28	30	*	40
TRICHLOROETHYLENE	20	0	0	.	*	.	.	*	.
VINYL CHLORIDE	20	0	0	.	*	.	.	*	.
ALDRIN	21	0	0	.	*	.	.	*	.
DIELDRIN	21	0	0	.	*	.	.	*	.
CHLORDANE	21	0	0	.	*	.	.	*	.
4,4-DDT	21	0	0	.	*	.	.	*	.
4,4-DDE	21	0	0	.	*	.	.	*	.
4,4-DDD	21	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	21	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	21	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	21	0	0	.	*	.	.	*	.
ENDRIN	21	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	21	0	0	.	*	.	.	*	.
HEPTACHLOR	21	0	0	.	*	.	.	*	.
HEPTACHLOR EPOXIDE	21	0	0	.	*	.	.	*	.
BHC-ALPHA	21	1	0	1.10	*	1.10	1.10	*	1.10
BHC-BETA	21	1	0	0.40	*	0.40	0.40	*	0.40
BHC (LINDANE)-GAMMA	21	2	0	2.24	*	2.24	2.24	*	2.24
BHC-DELTA	21	0	0	.	*	.	.	*	.
PCB-1242 (AROCHLOR 1242)	21	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	21	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	21	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	21	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	21	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	21	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	21	0	0	.	*	.	.	*	.

Table V-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	21	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	21	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	20	1	0	3	*	3	3	*	3
BENZO(A)ANTHRACENE/CHRYSENE	7	0	0	.	*	.	.	*	.
BENZO(3,4/K)FLUORANTHENE	7	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	44	14	4	1	1	3	7	18	27
ARSENIC (TOTAL)	44	16	2	2	2	4	11	21	72
BERYLLIUM (TOTAL)	44	4	0	0	*	1	1	*	2
CADMIUM (TOTAL)	44	6	5	6	*	15	14	*	21
CHROMIUM (TOTAL)	44	23	21	8	9	39	43	65	109
COPPER (TOTAL)	44	24	12	4	5	10	13	28	42
CYANIDE (TOTAL)	28	3	0	2	*	4	6	*	8
LEAD (TOTAL)	44	15	8	2	2	15	33	80	94
MERCURY (TOTAL)	44	20	1	0.27	0.30	0.55	1.47	1.87	13.00
NICKEL (TOTAL)	44	13	13	30	30	62	98	170	365
SELENIUM (TOTAL)	44	11	2	2	2	3	20	23	160
SILVER (TOTAL)	44	8	5	10	*	13	14	*	22
THALLIUM (TOTAL)	44	7	2	1	*	2	6	*	23
ZINC (TOTAL)	44	35	32	7	11	50	91	133	1100

Table V-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	40	40	500	1600	16400	80675	209999	871000
PH (UNITS)	40	40	6.3	7.0	7.8	7.8	8.3	9.4
IRON (TOTAL)	44	43	11	113	384	1842	2710	39040
MANGANESE (TOTAL)	43	35	3	8	142	526	923	7000
ASBESTOS(TOTAL-FIBERS/LITER)	7	7	3300E4	*	1090E6	1132E7	*	4100E7
COD	28	26	40	7000	17200	156620	89867	3260E3
DISSOLVED SOLIDS	16	16	85000	203200	880000	1315E3	2940E3	3200E3
TOTAL VOLATILE SOLIDS	20	19	10000	51700	136500	3785E3	681586	6700E4
VOLATILE SUSPENDED SOLIDS	15	10	1000	1000	2600	24280	12000	200000
SETTLEABLE SOLIDS	24	20	0.0	0.0	0.1	99.0	10.0	1800.0
TOTAL ORGANIC CARBON	27	22	5533	6800	10833	32770	57407	133000
MO ALKALINITY (CACO3)	17	17	40000	82000	295000	331353	583000	600000
PHENOLICS(4AAP)	27	6	2	*	16	18	*	40
TOTAL ACIDITY (CACO3)	1	1	10500	*	10500	10500	*	10500
TOTAL SOLIDS	18	18	260000	268000	920000	1188E4	3292E3	1800E5

Table V-7

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	7	3	0	3	*	3	3	*	3
ACROLEIN	7	0	0	.	*	.	.	*	.
ACRYLONITRILE	7	0	0	.	*	.	.	*	.
BENZENE	7	2	1	3	*	3	9	*	15
BENZIDENE	7	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	7	0	0	.	*	.	.	*	.
CHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	7	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	7	2	1	3	*	3	13	*	23
HEXACHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	7	0	0	.	*	.	.	*	.
CHLOROETHANE	7	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	7	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	7	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	7	1	0	3	*	3	3	*	3
2,4,6-TRICHLOROPHENOL	7	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	7	0	0	.	*	.	.	*	.
CHLOROFORM	7	2	1	5	*	5	17	*	29
2-CHLOROPHENOL	7	1	1	86	*	86	86	*	86
1,2-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	7	0	0	.	*	.	.	*	.

Table V-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	7	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	7	0	0	.	*	.	.	*	.
2,4-DICHLOROPHENOL	7	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	7	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	7	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	7	3	3	18	*	20	21	*	24
2,4-DINITROTOLUENE	7	1	1	18	*	18	18	*	18
2,6-DINITROTOLUENE	7	1	1	30	*	30	30	*	30
1,2-DIPHENYLHYDRAZINE	7	1	0	3	*	3	3	*	3
ETHYLBENZENE	7	1	0	3	*	3	3	*	3
FLUORANTHENE	7	5	2	3	*	3	6	*	11
4-CHLOROPHENYL PHENYL ETHER	7	1	0	3	*	3	3	*	3
4-BROMOPHENYL PHENYL ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	7	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	7	4	2	3	*	7	125	*	292
METHYL CHLORIDE	7	0	0	.	*	.	.	*	.
METHYL BROMIDE	7	0	0	.	*	.	.	*	.
BROMOFORM	7	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	7	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	7	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	7	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	7	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	7	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	7	0	0	.	*	.	.	*	.
ISOPHORONE	7	1	1	307	*	307	307	*	307
NAPHTHALENE	7	8	4	3	*	43	121	*	410
NITROBENZENE	7	1	1	21	*	21	21	*	21

Table V-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	7	1	1	17	*	17	17	*	17
4-NITROPHENOL	7	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	7	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	7	1	1	194	*	194	194	*	194
N-NITROSODIMETHYLAMINE	7	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	7	1	1	45	*	45	45	*	45
N-NITROSODI-N-PROPYLAMINE	7	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	7	0	0	.	*	.	.	*	.
PHENOL	7	4	1	3	*	3	8	*	16
BIS(2-ETHYLHEXYL, PHTHALATE	7	5	3	3	*	6	19	*	48
BUTYL BENZYL PHTHALATE	7	3	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	7	5	0	3	*	3	3	*	3
DI-N-OCTYL PHTHALATE	7	1	0	3	*	3	3	*	3
DIETHYL PHTHALATE	7	4	0	3	*	3	3	*	3
DIMETHYL PHTHALATE	7	1	0	3	*	3	3	*	3
BENZO(A)ANTHRACENE	7	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	7	4	2	3	*	3	40	*	141
BENZO(B)FLUORANTHENE	7	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	7	0	0	.	*	.	.	*	.
CHRYSENE	7	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	7	1	1	9	*	9	9	*	9
ANTHRACENE	7	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	7	3	1	3	*	3	4	*	7
FLUORENE	7	4	2	3	*	3	17	*	44
PHENANTHRENE	7	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	7	2	0	3	*	3	3	*	3
INDENO(1,2,3-C,D)PYRENE	7	1	0	3	*	3	3	*	3
PYRENE	7	5	2	3	*	3	10	*	25

Table V-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	7	0	0	.	*	.	.	*	.
TOLUENE	7	3	1	3	*	3	5	*	9
TRICHLOROETHYLENE	7	1	0	3	*	3	3	*	3
VINYL CHLORIDE	7	0	0	.	*	.	.	*	.
ALDRIN	6	1	0	6.40	*	6.40	6.40	*	6.40
DIELDRIN	6	3	0	2.24	*	2.24	2.26	*	2.30
CHLORDANE	7	0	0	.	*	.	.	*	.
4,4-DDT	8	0	0	.	*	.	.	*	.
4,4-DDE	8	1	0	2.24	*	2.24	2.24	*	2.24
4,4-DDD	8	1	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN-ALPHA	8	3	0	0.10	*	1.17	1.52	*	2.24
ENDOSULFAN-BETA	8	2	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN SULFATE	7	0	0	.	*	.	.	*	.
ENDRIN	7	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	8	2	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR	8	1	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR EPOXIDE	6	3	0	0.20	*	1.22	1.56	*	2.24
BHC-ALPHA	8	3	0	2.24	*	2.24	2.38	*	2.60
BHC-BETA	6	3	0	1.40	*	1.82	1.96	*	2.24
BHC (LINDANE)-GAMMA	6	3	0	0.43	*	1.33	1.63	*	2.24
BHC-DELTA	8	3	0	0.23	*	1.23	1.57	*	2.24
PCB-1242 (AROCHLOR 1242)	7	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	7	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	7	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	7	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	7	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	7	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	7	0	0	.	*	.	.	*	.

Table V-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	7	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	7	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	7	6	3	3	*	3	32	*	104
BENZO(A)ANTHRACENE/CHRYSENE	6	5	2	3	*	4	18	*	49
BENZO(3,4/K)FLUORANTHENE	6	3	1	3	*	3	4	*	7
ANTIMONY (TOTAL)	13	6	3	2	*	2	18	*	50
ARSENIC (TOTAL)	13	12	12	37	40	240	1072	2408	8500
BERYLLIUM (TOTAL)	13	9	8	3	*	38	93	*	450
CADMIUM (TOTAL)	13	6	6	13	*	34	102	*	290
CHROMIUM (TOTAL)	13	11	11	29	36	418	1260	2582	7500
COPPER (TOTAL)	13	13	13	100	138	1150	2106	6280	6500
CYANIDE (TOTAL)	7	0	0	.	*	.	.	*	.
LEAD (TOTAL)	13	12	12	24	33	760	1453	4287	5500
MERCURY (TOTAL)	13	7	4	1.00	*	11.25	17.85	*	43.00
NICKEL (TOTAL)	13	10	10	300	300	933	1537	2800	5500
SELENIUM (TOTAL)	13	10	9	3	3	40	137	350	470
SILVER (TOTAL)	13	8	6	6	*	22	28	*	64
THALLIUM (TOTAL)	13	9	4	.7	*	9	16	*	31
ZINC (TOTAL)	13	12	12	480	546	2867	4484	9660	13500

Table V-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	12	12	9131E3	9776E3	3440E4	6244E4	1875E5	2400E5
PH (UNITS)	12	12	4.2	4.7	7.3	7.2	8.0	8.1
IRON (TOTAL)	13	13	70000	77200	876250	825372	1850E3	2300E3
MANGANESE (TOTAL)	13	13	1075	1282	6067	8337	17900	25000
ASBESTOS(TOTAL-FIBERS/LITER)	1	1	5100E6	*	5100E6	5100E6	*	5100E6
COD	7	7	1470E4	*	3430E4	6123E4	*	2220E5
DISSOLVED SOLIDS	5	5	650000	*	1055E3	1372E3	*	2500E3
TOTAL VOLATILE SOLIDS	7	7	7567E3	*	2191E4	2893E4	*	8051E4
VOLATILE SUSPENDED SOLIDS	2	2	2000E3	*	2000E3	1500E4	*	2800E4
SETTLEABLE SOLIDS	11	11	56.3	60.7	224.3	367.4	835.0	880.0
TOTAL ORGANIC CARBON	7	7	1100E3	*	4137E3	8446E3	*	2847E4
MO ALKALINITY (CACO3)	5	5	160000	*	260000	1356E3	*	5400E3
PHENOLICS(4AAP)	7	4	20	*	25	63	*	155
TOTAL SOLIDS	2	2	9600E3	*	9600E3	2380E4	*	3800E4

Table V-8

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	4	0	0	.	*	.	.	*	.
ACROLEIN	4	0	0	.	*	.	.	*	.
ACRYLONITRILE	4	0	0	.	*	.	.	*	.
BENZENE	4	2	2	44	*	44	46	*	48
BENZIDENE	4	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	4	0	0	.	*	.	.	*	.
CHLOROBENZENE	4	1	1	12	*	12	12	*	12
1,2,3-TRICHLOROBENZENE	4	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	4	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	4	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	4	0	0	.	*	.	.	*	.
HEXACHLOROETHANE	4	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	4	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	4	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	4	0	0	.	*	.	.	*	.
CHLOROETHANE	4	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	4	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	4	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	4	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	4	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	4	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	4	0	0	.	*	.	.	*	.
CHLOROFORM	4	2	2	45	*	45	261	*	478
2-CHLOROPHENOL	4	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	4	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	4	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	4	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	4	0	0	.	*	.	.	*	.

Table V-8 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	4	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	4	0	0	.	*	.	.	*	.
2,4-DICHLOROPHENOL	4	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	4	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	4	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	4	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	4	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	4	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	4	0	0	.	*	.	.	*	.
ETHYLBENZENE	4	0	0	.	*	.	.	*	.
FLUORANTHENE	4	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	4	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	4	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	4	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	4	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	4	4	4	162	*	348	763	*	1440
METHYL CHLORIDE	4	0	0	.	*	.	.	*	.
METHYL BROMIDE	4	0	0	.	*	.	.	*	.
BROMOFORM	4	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	4	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	4	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	4	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	4	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	4	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	4	0	0	.	*	.	.	*	.
ISOPHORONE	4	0	0	.	*	.	.	*	.
NAPHTHALENE	4	0	0	.	*	.	.	*	.
NITROBENZENE	4	0	0	.	*	.	.	*	.

Table V-8 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	4	0	0	.	*	.	.	*	.
4-NITROPHENOL	4	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	4	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	4	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	4	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	4	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	4	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	4	0	0	.	*	.	.	*	.
PHENOL	4	0	0	.	*	.	.	*	.
BIS(2-ETHYLHEXYL) PHTHALATE	4	2	0	3	*	3	7	*	10
BUTYL BENZYL PHTHALATE	4	0	0	.	*	.	.	*	.
DI-N-BUTYL PHTHALATE	4	0	0	.	*	.	.	*	.
DI-N-OCTYL PHTHALATE	4	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	4	0	0	.	*	.	.	*	.
DIMETHYL PHTHALATE	4	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	4	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	4	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	4	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	4	0	0	.	*	.	.	*	.
CHRYSENE	4	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	4	0	0	.	*	.	.	*	.
ANTHRACENE	4	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	4	0	0	.	*	.	.	*	.
FLUORENE	4	0	0	.	*	.	.	*	.
PHENANTHRENE	4	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	4	0	0	.	*	.	.	*	.
INDENO(1,2,3-C,D)PYRENE	4	0	0	.	*	.	.	*	.
PYRENE	4	0	0	.	*	.	.	*	.

Table V-8 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	4	0	0	.	*	.	.	*	.
TOLUENE	4	3	2	10	*	12	17	*	27
TRICHLOROETHYLENE	4	0	0	.	*	.	.	*	.
VINYL CHLORIDE	4	0	0	.	*	.	.	*	.
ALDRIN	4	0	0	.	*	.	.	*	.
DIELDRIN	4	0	0	.	*	.	.	*	.
CHLORDANE	4	0	0	.	*	.	.	*	.
4,4-DDT	4	0	0	.	*	.	.	*	.
4,4-DDE	4	0	0	.	*	.	.	*	.
4,4-DDD	4	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	4	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	4	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	4	0	0	.	*	.	.	*	.
ENDRIN	4	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	4	0	0	.	*	.	.	*	.
HEPTACHLOR	4	0	0	.	*	.	.	*	.
HEPTACHLOR EPOXIDE	4	0	0	.	*	.	.	*	.
BHC-ALPHA	4	0	0	.	*	.	.	*	.
BHC-BETA	4	1	0	0.33	*	0.33	0.33	*	0.33
BHC (LINDANE)-GAMMA	4	0	0	.	*	.	.	*	.
BHC-DELTA	4	1	0	0.10	*	0.10	0.10	*	0.10
PCB-1242 (AROCHLOR 1242)	4	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	4	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	4	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	4	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	4	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	4	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	4	0	0	.	*	.	.	*	.

Table V-8 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	4	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	4	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	4	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE/CHRYSENE	1	0	0	.	*	.	.	*	.
BENZO(3,4/K)FLUORANTHENE	1	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	9	3	1	2	*	5	13	*	28
ARSENIC (TOTAL)	9	4	2	2	*	3	350	*	1340
BERYLLIUM (TOTAL)	9	4	2	2	*	4	60	*	220
CADMIUM (TOTAL)	9	3	3	13	*	18	25	*	38
CHROMIUM (TOTAL)	9	7	6	10	*	61	235	*	980
COPPER (TOTAL)	9	7	5	6	*	44	232	*	1000
CYANIDE (TOTAL)	4	0	0	.	*	.	.	*	.
LEAD (TOTAL)	9	4	3	3	*	30	271	*	1000
MERCURY (TOTAL)	9	4	0	0.20	*	0.70	1.10	*	2.40
NICKEL (TOTAL)	9	7	7	38	*	232	1771	*	10000
SELENIUM (TOTAL)	9	4	3	1	*	21	137	*	450
SILVER (TOTAL)	9	2	2	27	*	27	31	*	36
THALLIUM (TOTAL)	9	1	1	14	*	14	14	*	14
ZINC (TOTAL)	9	8	8	19	*	240	4297	*	30000

Table V-8 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	7	7	3300	*	20200	67064	*	240000
PH (UNITS)	7	7	2.4	*	5.8	5.4	*	7.2
IRON (TOTAL)	9	9	275	*	3700	1246E3	*	9000E3
MANGANESE (TOTAL)	9	9	27	*	2237	17436	*	80000
COD	4	4	12675	*	15500	362044	*	1160E3
DISSOLVED SOLIDS	3	3	580000	*	1390E3	1960E3	*	3100E3
TOTAL VOLATILE SOLIDS	4	4	26000	*	64250	1398E3	*	2900E3
VOLATILE SUSPENDED SOLIDS	4	4	2200	*	4800	10250	*	28000
SETTLEABLE SOLIDS	3	2	0.0	*	0.0	0.0	*	0.0
TOTAL ORGANIC CARBON	4	3	4125	*	7612	11508	*	19300
FREE ACIDITY (CACO3)	1	1	740000	*	740000	740000	*	740000
MO ALKALINITY (CACO3)	2	2	1000	*	1000	21500	*	42000
PHENOLICS(4AAP)	4	0	.	*	.	.	*	
SULFATE	1	1	310000	*	310000	310000	*	310000
TOTAL SOLIDS	4	4	180000	*	410000	9147E3	*	2200E4

Table V-9

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY AREAS UNDER RECLAMATION
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	15	13	13	66	68	101	117	186	235
ARSENIC (TOTAL)	15	4	4	66	*	79	328	*	890
BERYLLIUM (TOTAL)	15	8	3	1	*	4	6	*	12
CADMIUM (TOTAL)	15	6	6	11	*	16	19	*	40
CHROMIUM (TOTAL)	15	12	9	6	6	17	37	101	116
COPPER (TOTAL)	15	14	13	8	8	19	44	114	131
LEAD (TOTAL)	15	4	4	30	*	37	59	*	103
MERCURY (TOTAL)	15	1	1	40.00	*	40.00	40.00	*	40.00
NICKEL (TOTAL)	15	8	8	45	*	85	258	*	996
SELENIUM (TOTAL)	15	2	2	70	*	70	74	*	77
SILVER (TOTAL)	15	4	0	5	*	5	5	*	6
THALLIUM (TOTAL)	15	3	3	147	*	149	161	*	184
ZINC (TOTAL)	15	15	15	7	10	71	1160	1828	12644

Table V-9 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY AREAS UNDER RECLAMATION
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS		DETECTED CONCENTRATIONS IN UG/L				
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	16	16	12733	12859	72139	338101	987480	1945E3
PH (UNITS)	16	16	5.1	5.9	7.5	7.3	7.9	8.0
IRON (TOTAL)	16	16	241	505	2365	12655	35550	65683
MANGANESE (TOTAL)	15	15	94	94	390	1407	1770	11805
SETTLEABLE SOLIDS	14	11	0.0	0.0	0.3	4.6	6.0	39.0

Table V-10

COMPARISON OF CLASSICAL POLLUTANTS IN ALKALINE SURFACE AND UNDERGROUND MINES

Mean Values (mg/l)

	Raw		Treated	
Pollutant	Surface	Deep	Surface	Deep
TSS	141	40	36	39
Iron	1.52	0.41	1.26	0.68
Manganese	0.82	0.076	0.39	0.29

Table V-11

COMPARISON OF CLASSICAL POLLUTANTS IN ACID SURFACE AND UNDERGROUND MINES

Mean Values (mg/l)

	Raw		Treated	
Pollutant	Surface	Deep	Surface	Deep
TSS	732	158	32	21.1
Iron	45.7	135	1.21	1.72
Manganese	17.7	4.9	2.45	1.27

Table V-12

COMPARISON OF MEDIAN TOXIC METAL CONCENTRATIONS IN ACID AND ALKALINE SURFACE AND UNDERGROUND MINES
(in ug/1)

	Raw				Treated			
	Acid		Alkaline		Acid		Alkaline	
Pollutant	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep
Antimony	--	2.5	6	2	8	2.5	6	2
Arsenic	210	23	3	5	11	18	4	4.4
Beryllium	23	12	2	ND	ND	ND	2	ND
Cadmium	98	6	ND	ND	ND	ND	ND	ND
Chromium	187	30	32	49	126	24	33	49
Copper	150	82	10	6	14	13	10	6
Lead	323	51	23	72	ND	102	23	72
Mercury	1.3	0.9	0.4	0.6	0.3	1.0	0.5	0.6
Nickel	2020	400	30	57	95	5	30	57
Selenium	17	34	3.5	3	13	14	3	3
Silver	ND	5	10	ND	ND	5	10	ND
Thallium	ND	1	2	2	2	1	1.5	1.7
Zinc	6620	510	80	56	29	49	70	56

Source: Screening and Verification Data

Table V-13

PREPARATION PLANTS VERSUS ASSOCIATED AREAS UNTREATED WATER

Parameter	Preparation Plants Total Samples				Associated Areas Total Samples			
	Total Samples	Total Detects	Detects >10 ppb	Median* (mg/l)	Total Samples	Total Detects	Detects >10 ppb	Median* (mg/l)
Antimony	11	6	3	.002	8	3	1	.005
Arsenic	11	10	10	.200	8	4	2	.003
Beryllium	11	7	7	.036	8	4	2	.004
Cadmium	11	4	4	.034	8	3	3	.018
Chromium	11	9	9	.502	8	7	6	.061
Copper	11	11	11	.860	8	7	5	.044
Lead	11	10	10	.760	8	4	3	.030
Mercury	11	6	4	.015	8	4	0	
Nickel	11	8	8	.933	8	6	6	.330
Selenium	11	8	7	.050	8	4	3	.021
Silver	11	6	4	.019	8	2	2	.027
Thallium	11	7	4	.010	8	1	1	.014
Zinc	11	10	10	2.9	8	7	7	.266
Iron	11	11	11	841**	8	8	8	1402**
Manganese	11	11	11	8.5**	8	8	8	19**
TSS	10	10		69,330**	6	6		77**
pH (units)	10	10		7.1	6	6		5.1

* This is the median of all values >10 ppb.

** Mean

Sources: Screening and Verification Data;
Engineering Site Visit Data

Table V-14

PREPARATION PLANT PROCESS EFFLUENT TOTAL VERSUS DISSOLVED METALS

	Preparation Plant A (mg/1)		Preparation Plant B (mg/1)		Preparation Plant C (mg/1)	
	Total Metals	Dissolved Metals	Total Metals	Dissolved Metals	Total Metals	Dissolved Metals
Antimony	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic	0.037	<0.002	2.7	<0.002	6.5	<0.002
Beryllium	0.016	<0.001	0.012	<0.001	0.016	<0.001
Cadmium	0.034	<0.005	0.29	0.016	0.17	<0.005
Chromium	0.098	0.009	0.92	0.032	0.47	0.013
Copper	0.33	0.006	6.4	0.037	6.0	0.020
Iron	94	0.097	2,300	2.4	1,000	1.0
Lead	0.071	0.003	1.0	<0.002	0.024	<0.002
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	1.7	0.047	13	0.71	12	0.12
Nickel	0.33	0.026	2.8	<0.020	2.1	<0.020
Selenium	<0.005	<0.005	0.21	<0.005	0.35	<0.005
Silver	0.019	0.009	0.064	0.026	0.057	0.019
Thallium	<0.002	<0.002	0.026	<0.002	0.008	<0.002
Zinc	0.98	<0.002	8.3	0.015	6.0	0.007

Source: Engineering Site Visit Data

Table V-15

COMPARISON OF ANTHRACITE AND ACID RAW WASTEWATER

	Anthracite Mines			Acid Mines		
Pollutant	Total Number Samples	Total Detects	Median Value (mg/l)	Total Number Samples	Total Detects	Median Value (mg/l)
TSS	5	5	56*	22	21	440*
Iron	5	5	34*	22	22	88*
Manganese	5	5	6.7*	22	21	8.2*
pH (units)	5	5	4.3	24	24	5.3
			(ug/l)			(ug/l)
Sb	5	0	--	21	8	2
As	5	1	26	22	14	31
Be	5	3	7	22	7	10
Cd	5	0	--	22	3	11
Cr	5	4	40	22	11	41
Cu	5	5	20	22	16	48
Pb	5	3	9	22	6	18
Hg	5	0	--	22	11	1.1
Ni	5	5	50	22	11	140
Se	5	0	--	22	11	28
Ag	5	2	11	22	7	13
Tl	5	0	--	22	5	1
Zn	5	5	520	22	20	460

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*Mean value

Table V-16

EASTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	14	14	2600	3160	17000	67364	170240	330000
PH (UNITS)	14	14	6.6	6.8	7.6	7.6	8.1	8.7
TOTAL IRON	17	17	11	98	537	1094	2590	3500
MANGANESE (TOTAL)	17	17	3	25	475	935	1430	7000

Table V-17

EASTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	17	3	0	2	*	2	3	*	6
ARSENIC (TOTAL)	17	4	1	2	*	2	12	*	40
BERYLLIUM (TOTAL)	17	2	0	2	*	2	2	*	2
CADMIUM (TOTAL)	17	3	2	6	*	10	14	*	21
CHROMIUM (TOTAL)	17	10	9	8	8	33	42	65	109
COPPER (TOTAL)	17	4	3	10	*	13	20	*	42
LEAD (TOTAL)	17	8	4	2	*	8	29	*	94
MERCURY (TOTAL)	17	7	0	0.30	*	0.44	1.06	*	2.20
NICKEL (TOTAL)	17	7	7	30	*	67	115	*	365
SELENIUM (TOTAL)	17	4	0	4	*	6	6	*	7
SILVER (TOTAL)	17	6	3	10	*	10	13	*	22
THALLIUM (TOTAL)	17	1	0	2	*	2	2	*	2
ZINC (TOTAL)	17	13	10	7	7	31	52	138	156

Table V-18

WESTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	11	11	500	510	65250	153361	292000	871000
PH (UNITS)	11	11	6.9	7.0	7.7	7.7	8.1	8.2
TOTAL IRON	11	11	64	68	1317	4996	5250	39040
MANGANESE (TOTAL)	11	11	4	4	90	172	222	947

Table V-19

WESTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	11	3	2	6	*	8	14	*	27
ARSENIC (TOTAL)	11	3	0	4	*	4	6	*	8
BERYLLIUM (TOTAL)	11	2	0	0	*	0	1	*	1
CADMIUM (TOTAL)	11	2	2	11	*	11	14	*	17
CHROMIUM (TOTAL)	11	5	4	8	*	44	42	*	57
COPPER (TOTAL)	11	11	6	4	4	10	14	27	36
LEAD (TOTAL)	11	1	0	4	*	4	4	*	4
MERCURY (TOTAL)	11	3	0	0.27	*	0.35	0.70	*	1.40
NICKEL (TOTAL)	11	1	1	174	*	174	174	*	174
SELENIUM (TOTAL)	11	3	0	2	*	2	3	*	3
SILVER (TOTAL)	11	0	0	.	*	.	.	*	.
THALLIUM (TOTAL)	11	0	0	.	*	.	.	*	.
ZINC (TOTAL)	11	10	10	13	13	80	184	186	1100

Table V-20

EASTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ALKALINE DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	MIN	DETECTED CONCENTRATIONS IN UG/L				
				10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	30	30	32	2900	17600	27282	73066	118067
PH (UNITS)	30	30	3.2	6.9	7.7	7.5	8.2	8.5
TOTAL IRON	30	29	54	127	565	1301	2820	5100
MANGANESE (TOTAL)	30	29	28	46	326	558	1330	2800

Table V-21

EASTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	30	7	1	1	*	2	5	*	15
ARSENIC (TOTAL)	30	13	3	2	2	5	8	13	22
BERYLLIUM (TOTAL)	30	0	0	.	*	.	.	*	.
CADMIUM (TOTAL)	30	5	4	5	*	14	14	*	23
CHROMIUM (TOTAL)	30	20	17	9	10	33	77	63	860
COPPER (TOTAL)	30	8	4	6	*	10	19	*	40
LEAD (TOTAL)	30	5	3	5	*	12	24	*	66
MERCURY (TOTAL)	30	13	0	0.10	0.16	0.50	1.34	1.67	7.90
NICKEL (TOTAL)	30	4	3	10	*	52	68	*	146
SELENIUM (TOTAL)	30	7	1	1	*	2	5	*	20
SILVER (TOTAL)	30	7	7	14	*	20	20	*	25
THALLIUM (TOTAL)	29	2	0	1	*	1	1	*	2
ZINC (TOTAL)	30	19	15	7	9	19	47	103	188

Table V-22

WESTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ALKALINE DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

			DETECTED CONCENTRATIONS IN UG/L					
COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	11	11	2400	2720	9650	21724	28893	97000
PH (UNITS)	11	11	7.5	7.5	7.9	8.0	8.4	8.5
TOTAL IRON	11	10	140	140	349	474	1030	1200
MANGANESE (TOTAL)	11	11	17	18	44	103	242	285

Table V-23

WESTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	11	3	2	3	*	7	10	*	15
ARSENIC (TOTAL)	11	3	0	3	*	4	5	*	6
BERYLLIUM (TOTAL)	11	1	0	0	*	0	0	*	0
CADMIUM (TOTAL)	11	1	0	9	*	9	9	*	9
CHROMIUM (TOTAL)	11	4	3	8	*	11	30	*	50
COPPER (TOTAL)	11	7	2	3	*	9	9	*	15
LEAD (TOTAL)	11	3	1	2	*	5	40	*	109
MERCURY (TOTAL)	11	2	0	0.83	*	0.83	1.72	*	2.60
NICKEL (TOTAL)	11	0	0	.	*	.	.	*	.
SELENIUM (TOTAL)	11	1	0	2	*	2	2	*	2
SILVER (TOTAL)	11	0	0	.	*	.	.	*	.
THALLIUM (TOTAL)	11	1	0	1	*	1	1	*	1
ZINC (TOTAL)	10	6	6	14	*	45	63	*	127

Table V-24

COAL MINE DMR DATA
1979 AVERAGE TSS & Fe VALUES*:
ALKALINE EASTERN VS. ALKALINE WESTERN FACILITIES

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Overall Ave. Values 1979
WESTERN **													
TSS (mg/l)													
Ave. Maximum Value	23.9	24.2	37.2	34.9	27.1	19.1	26.3	21.4	23.0	9.8	13.3	15.8	23.0
Ave. Minimum Value	4.2	4.5	7.3	7.3	5.2	7.2	6.4	5.2	4.6	3.3	5.4	6.6	5.6
Ave. Average Value	16.3	15.3	19.8	18.3	14.3	13.4	14.4	11.4	12.2	6.5	8.6	10.7	13.4
Fe (mg/l)													
Ave. Maximum Value	1.02	1.03	1.00	0.88	0.86	0.54	0.75	1.08	0.81	0.58	0.84	0.35	0.81
Ave. Minimum Value	0.36	0.36	0.25	0.10	0.10	0.17	0.28	0.28	0.31	0.19	0.18	0.13	0.23
Ave. Average Value	0.69	0.67	1.27	0.40	0.45	0.34	0.47	0.60	0.45	0.50	0.65	0.24	0.56
EASTERN**													
TSS (mg/l)													
Ave. Maximum Value	27.3	4.4	19.9	20.4	92.5	9.4	18.0	31.1	25.6	81.0	17.9	46.0	32.8
Ave. Minimum Value	5.5	3.8	9.2	22.2	63.2	5.9	17.0	9.2	6.7	3.0	4.1	36.3	15.5
Ave. Average Value	16.3	12.4	11.3	16.0	48.9	11.6	13.5	17.2	11.2	21.8	7.8	27.8	18.0
Fe (mg/l)													
Ave. Maximum Value	1.09	1.0	0.82	0.45	1.79	0.52	1.16	0.80	0.78	0.45	1.00	1.01	0.91
Ave. Minimum Value	0.44	0.22	0.39	0.35	1.5	0.48	1.03	0.56	0.70	0.02	0.30	0.53	0.54
Ave. Average Value	0.65	0.41	0.42	0.35	1.3	0.39	1.0	0.49	0.5	0.73	0.44	0.93	0.63

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* Values do not include instances of "No Discharge," "No Reported Values," or violations due to precipitation events.

** Includes data from 10 Western facilities and 10 Eastern facilities.

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

INTRODUCTION

The Agency has studied coal mining wastewaters to determine the presence or absence of toxic, conventional, and non-conventional pollutants. This section will address the selection of pollutant parameters in effluents that have undergone BPT treatment. The quantities and treatability of pollutants in these treated wastewaters will form the basis for selection of pollutant parameters for regulation.

The CWA requires that effluent limitations be established for toxic pollutants referred to in Section 307(a)(1). These pollutants, and the conventional and selected nonconventional pollutants are summarized in Table VI-1.

The Settlement Agreement in Natural Resources Defense Council, Incorporated vs. Train, 8 ERC 2120 (D.D.C. 1976), modified 9 March 1979, provides for the exclusion of particular pollutants, categories and subcategories (Paragraph 8), according to the criteria summarized below:

1. Equal or more stringent protection is already provided by EPA's guidelines and standards under the Act.

2. The pollutant is present in the effluent discharge solely as a result of its presence in the intake water taken from the same body of water into which it is discharged.

3. The pollutant is not detectable in the effluent within the category by approved analytical methods or methods representing the state-of-the-art capabilities. (Note: this includes cases in which the pollutant is present solely as a result of contamination during sampling and analysis by sources other than the wastewater.)

4. The pollutant is detected in only a small number of sources within the category and is uniquely related to only those sources.

5. The pollutant is present only in trace amounts and is neither causing nor likely to cause toxic effects.

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*Figures and tables appear at the end of this section.

6. The pollutant is present in amounts too small to be effectively reduced by known technologies.

7. The pollutant is effectively controlled by the technologies upon which other effluent limitations and guidelines are based.

All pollutants detected in treated effluents of the coal mining industry are summarized in Table VI-2. These results are also summarized by subcategory in Tables VI-3 through VI-7.

POLLUTANTS SELECTED FOR REGULATION IN THE COAL MINING POINT SOURCE CATEGORY

Specific effluent limitations are being established for total suspended solids, pH, iron and manganese for each subcategory except post mining discharges from reclamation areas; settleable solids and pH have been selected to control these effluents and also discharges during rainfall events.

POLLUTANTS EXCLUDED FROM REGULATION

All of the organic priority pollutants are excluded from regulation. The reasons for exclusion are presented in Table VI-8 and are discussed below. It should be noted that one additional acid mine was sampled very late in the BAT program. Although the data collected from this mine is included in the summary tables in this section, time did not permit the incorporation of the results into the following discussion. Two of the organic pollutants, benzo(a)pyrene and benzo(k)fluoranthene, were detected on one day at 8 and 13 ug/l, respectively. Subsequent drafts of this document will include benzo(a)pyrene as a pollutant detected at two or less mines at a concentration of less than 10 ug/l (Table VI-14), and benzo(k)fluoranthene as a pollutant present at concentrations too small to be effectively reduced (Table VI-15).

Pollutants Not Detected in Treated Effluents

The Settlement Agreement provides for the exclusion from regulation of toxic pollutants not detectable by approved methods or methods representing state-of-the-art capabilities. The sixty-seven organic priority pollutants not detected during sampling and thus excluded from regulation are listed in Table VI-9.

Pollutants Detected Due to Laboratory Analysis and Field Sampling Contamination

Ten of the priority organics were detected in one or more of the treated effluent samples; however, their presence is believed to be the sole result of contamination by sources in the field or laboratory independent of the wastewater samples. Table VI-10 tabulates the pollutants in this category. The sources of contamination are discussed in detail below.

Field controls and blanks were used during each phase of the sampling program (Screening, Verification, and EPA Regional Sampling and Analysis). The field controls consisted of water that was run through the automatic sampler at each composite sample site prior to the actual sampling. The water used as control water was deionized and as such, any contaminants appearing in the collected control water could be attributed to the sampling apparatus or to the laboratory analysis. The results are found for all subcategories in Table VI-11. Field blanks were also collected to assess contamination in transport and in laboratory analysis. For the volatile organics, deionized water was placed in 45 ml to 125 ml vials. For the remainder of the priority pollutants, a facility blank, prepared in the laboratory, was hand-carried by sampling personnel during field sampling. Table VI-12 summarizes the blanks for the screening and verification sampling and analysis program.

Table VI-2 indicates that members of the phthalate class were observed in many of the samples representing treated wastewater. Only two of the phthalates (bis-phthalate and di-n-butyl phthalate) were detected in the raw water (refer to Table V-4); however, five of the phthalates (bis-phthalate, di-n-butyl phthalate, butyl benzyl phthalate, di-n-octyl phthalate, and diethyl phthalate) were detected in treated water. This suggests that these compounds were introduced into the water during sample collection or analysis. It is known that during sample collection, automatic composite samplers were equipped with polyvinyl chloride (Tygon) tubing or manufacturer supplied tubing. Phthalates are widely used as plasticizers to ensure that tubing remains soft and flexible (2). These compounds, added during manufacturing, have a tendency to migrate to the surface of tubing and leach out into water passing through the sample tubing. In addition, laboratory experiments were performed to determine if phthalates and other priority pollutants could be leached from tubing used on automatic samplers (3). The types of tubing used in these experiments were:

(1) Clear tubing originally supplied with the sampler at time of purchase; and

(2) Tygon S-50-HL, Class VI.

Results of analysis of the extracts representing the original and replacement Tygon tubings are summarized in Table VI-13. The data indicate that both types contain bis(2-ethylhexyl)phthalate and the original tubing leaches high concentrations of phenol. Although bis(2-ethylhexyl)phthalate was the only phthalate detected in the tubing in these experiments, a similar experiment conducted as part of a study pursuant to the development of BAT Effluent Limitations Guidelines for the Textiles Point Source Category found dimethyl phthalate, diethyl phthalate, di-n-butyl phthalate, and bis(2-ethylhexyl)phthalate, in tubing "controls" (4). Thus, four of the phthalates [bis(2-ethylhexyl)phthalate, butylbenzyl phthalate, di-n-butyl phthalate, diethyl phthalate] and phenol can be attributed to contamination during sample collection and cannot be conclusively identified with the wastewater.

A number of the volatile organic compounds were detected during the sampling program (benzene, chloroform, methylene chloride, tetrachloroethylene, toluene). The volatile nature of these compounds suggests contamination as a possible source, especially considering the relatively low concentrations detected in the samples. More importantly, all of these compounds may be found in the laboratory as solvents, extraction agents or aerosol propellants. Thus, the presence and/or use of the compounds in the laboratory may be responsible for sample contamination. This type of contamination has been previously addressed in another study (5). In a review of a set of volatile organic blank analytical data from this study, inadvertent contamination was shown to have occurred for each of the above compounds (see Table VI-12).

Another contaminant is methylene chloride. This compound is separated and quantified with other volatile compounds. The organics analytical procedure involves the use of methylene chloride as a solvent (1), (5). Thus, the relatively high concentrations and the detection of this compound in 47 of 51 of the treated water samples (Table VI-2) may be explained by its use in analytical procedures.

Priority Organics Detected in Treated Effluents at One or Two Mines and Uniquely Related to Those Sources

The 23 pollutants in Table VI-14 were detected at two or less facilities and always at concentrations below 10 ug/l. One of these compounds is a member of the phthalate family, two are volatile organics, three are acid-extractable, twelve are base neutrals and five are pesticides. These organics are excluded from regulation since they are present at less than the nominal detection limit (10 ug/l) in two or less facilities within the category. This level was established by the Agency to indicate where background signals in the machines used for analysis begin to mask actual detection signals (i.e., the signal to noise ratio reaches approximately 2:1). Examination of Tables VI-11 and VI-12 shows that 14 of these compounds were also detected in at least one field blank or control sample.

Priority Organics Detected but Present in Amounts too Small to be Effectively Reduced

The 14 compounds in Table VI-15 were detected in treated effluents in this industry. The concentrations of these pollutants are so small that they cannot be substantially reduced. In some cases this is because no technologies are known to further reduce them beyond BPT; in other cases, the pollutant reduction cannot be accurately quantified because the analytical error at these low levels can be larger than the value itself. These 14 pollutants are thus excluded from regulation.

Therefore, all pollutants listed in Table VI-8 were determined to be excluded from regulation at this time.

Priority Metals Excluded from Regulation

Examination of Table VI-2 shows that five priority metals (antimony, beryllium, cadmium, silver and thallium) and cyanide were detected in effluents at more than two facilities. However, in all cases the detected concentrations were at levels only slightly above the detection limit for each respective species. This precludes any meaningful determination of the effectiveness of treatment beyond BPT technologies. Thus, antimony, beryllium, cadmium, cyanide, silver and thallium can be excluded from BAT regulation since they cannot be effectively reduced by known technologies.

The remaining eight (arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc) were sometimes found at concentrations above the detection limit in BPT-treated discharges. Paragraph 8(a)(iii) provides for exclusion of pollutants if these pollutants are already effectively controlled by technologies upon which other effluent limitations and guidelines are based. These eight metals are effectively controlled by BPT technology and thus were not selected for national regulation under BAT or NSPS. However, some of these metals appear in significant amounts for individual mines. This results from a number of factors, including:

(1) Differing trace element compositions in the precursor plant life that was later transformed into coal,

(2) Differing geologies of strata surrounding the coal, and

(3) Geographic variations.

In these cases, the permit authority should consider the imposition of a limitation for the pollutant of concern for the mine in question.

Table VI-1

LIST OF 129 PRIORITY POLLUTANTS, CONVENTIONALS AND NON-CONVENTIONALS (1)

Compound Name

1. *acenaphthene (B)
2. *acrolein (V)***
3. *acrylonitrile (V)
4. *benzene (V)
5. *benzidene (B)
6. *carbon tetrachloride (tetrachloromethane) (V)
7. chlorobenzene (V)
8. 1,2,4-trichlorobenzene (B)
9. hexachlorobenzene (B)
10. 1,2-dichloroethane (V)
11. 1,1,1-trichlorethane (V)
12. hexachlorethane (B)
13. 1,1-dichloroethane (V)
14. 1,1,2-trichloroethane (V)
15. 1,1,2,2-tetrachloroethane (V)
16. chloroethane (V)
17. bis (chloromethyl) ether (V)
18. bis (2-chloroethyl) ether (B)
19. 2-chloroethyl vinyl ether (mixed) (V)
20. 2-chloronaphthalene (B)
21. 2,4,6-trichlorophenol (A)***
22. parachlorometa cresol (A)
23. *chloroform (trichloromethane) (V)
24. *2-chlorophenol (A)
25. 1,2-dichlorobenzene (B)
26. 1,3-dichlorobenzene (B)
27. 1,4-dichlorobenzene (B)
28. 3,3'-dichlorobenzidine (B)
29. 1,1-dichloroethylene (V)
30. 1,2-trans-dischloroethylene (V)
31. *2,4-dichlorophenol (A)
32. 1,2-dichloropropane (V)
33. 1,2-dichloropropylene (1,3-dichloropropene) (V)
34. *2,4-dimenthylphenol (A)
35. 2,4-dinitrotoluene (B)
36. 2,6,-dinitrotoluene (B)
37. *1,2-diphenylhydrazine (B)
38. *ethylbenzene (V)
39. *fluoranthene (B)
40. 4-chlorophenyl phenyl ether (B)
41. 4-bromophnyl phenyl ether (B)
42. bis(2-chloroisopropyl) ether (B)

Table VI-1 (Continued)

LIST OF 129 PRIORITY POLLUTANTS, CONVENTIONALS AND NON-CONVENTIONALS (1)

43. bis(2-chloroethoxy) methane (B)
44. methylene chloride (dichloromethane) (V)
45. methyl chloride (chloromethane) (V)
46. methyl bromide (bromomethane) (V)
47. bromoform (tribromomethane) (V)
48. dichlorobromomethane (V)
49. trichlorofluoromethane (V)
50. dichlorodifluoromethane (V)
51. chlorodibromomethane (V)
52. *hexachlorobutadiene (B)
53. *hexachlorocyclopentadiene (B)
54. *isophorone (B)
55. *naphthalene (B)
56. *nitrobenzene (B)
57. 2-nitrophenol (A)
58. 4-nitrophenol (A)
59. *2,4-dinitrophenol (A)
60. 4,6-dinitro-o-cresol (A)
61. N-nitrosodimethylamine (B)
62. N-nitrosodiphenylamine (B)
63. N-nitrosodi-n-propylamine (B)
64. *pentachlorophenol (A)
65. *phenol (A)
66. bis(2-ethylhexyl) phthalate (B)
67. butyl benzyl phthalate (B)
68. di-n-butyl phthalate (B)
69. di-n-octyl phthalate (B)
70. diethyl phthalate (B)
71. dimethyl phthalate (B)
72. benzo (a)anthracene (1,2-benzanthracene) (B)
73. benzo (a)pyrene (3,4-benzopyrene) (B)
74. 3,4-benzofluoranthene (B)
75. benzo(k)fluoranthane (11,12-benzofluoranthene) (B)
76. chrysene (B)
77. acenaphthylene (B)
78. anthracene (B)
79. benzo(ghi)perylene (1,12-benzoperylene) (B)
80. fluorene (B)
81. phenathrene (B)
82. dibenzo (a,h)anthracene (1,2,5,6-dibenzanthracene) (B)
83. indeno (1,2,3-cd)(2,3,-o-phenylenepyrene) (B)
84. pyrene (B)
85. *tetrachloroethylene (V)
86. *toluene (V)

Table VI-1 (Continued)

LIST OF 129 PRIORITY POLLUTANTS, CONVENTIONALS AND NON-CONVENTIONALS (1)

87. *trichloroethylene (V)
88. *vinyl chloride (chloroethylene) (V)
89. *aldrin (P)
90. *dieldrin (P)
91. *chlordane (technical mixture and metabolites) (P)
92. 4,4'-DDT (P)
93. 4,4'-DDE(p,p'DDX) (P)
94. 4,4'-DDD(p,p'TDE) (P)
95. a-endosulfan-Alpha (P)
96. b-endosulfan-Beta (P)
97. endosulfan sulfate (P)
98. endrin (P)
99. endrin aldehyde (P)
100. heptachlor (P)
101. heptachlor epoxide (P)
102. a-AHC-alpha (P) (B)
103. b-BHC-beta (P) (V)
104. r-BHC (lindane)-gamma (P)
105. g-BHC-delta (P)
106. PCB-1242 (Arochlor 1242) (P)
107. PCB-1254 (Arochlor 1254) (P)
108. PCB-1221 (Arochlor 1221) (P)
109. PCB-1232 (Arochlor 1232) (P)
110. PCB-1248 (Arochlor 1248) (P)
111. PCB-1260 (Arochlor 1260) (P)
112. PCB-1016 (Arochlor 1016) (P)
113. *Toxaphene (P)
114. **2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (P)
115. *Antimony (Total)
116. *Arsenic (Total)
117. *Asbestos (Fibrous)
118. *Beryllium (Total)
119. *Cadmium (Total)
120. *Chromium (Total)
121. *Copper (Total)
122. *Cyanide (Total)
123. *Lead (Total)
124. *Mercury (Total)
125. *Nickel (Total)
126. *Selenium (Total)
127. *Silver (Total)
128. *Thallium (Total)
129. *Zinc (Total)

Table VI-1 (Continued)

LIST OF 129 PRIORITY POLLUTANTS, CONVENTIONALS AND NON-CONVENTIONALS (1)

Conventionals

pH
Total Suspended Solids

Non-Conventionals

Iron
Manganese
Chemical Oxygen Demand (COD)
Total Organic Carbon (TOC)
Settleable Solids (SS)

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*Specific compounds and chemical classes as listed in the consent degree.

**This compound was specifically listed in the consent degree.

***B = analyzed in the base-neutral extraction fraction
V = analyzed in the volatile organic fraction
A = analyzed in the acid extraction fraction
P = pesticide/polychlorinated diphenyl

Table VI-2

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	53	0	0	.	*	.	.	*	.
ACROLEIN	51	0	0	.	*	.	.	*	.
ACRYLONITRILE	51	0	0	.	*	.	.	*	.
BENZENE	51	21	2	0	0	2	4	7	16
BENZIDENE	53	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	51	0	0	.	*	.	.	*	.
CHLOROBENZENE	50	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	53	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	53	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	51	2	0	1	*	1	1	*	1
1,1,1-TRICHLOROETHANE	51	11	0	1	1	2	2	3	3
HEXACHLOROETHANE	53	1	0	3	*	3	3	*	3
1,1-DICHLOROETHANE	51	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	51	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	51	1	0	3	*	3	3	*	3
CHLOROETHANE	51	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	51	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	53	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	51	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	53	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	51	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	51	0	0	.	*	.	.	*	.
CHLOROFORM	51	40	22	1	3	13	60	126	476
2-CHLOROPHENOL	51	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	53	2	1	3	*	3	11	*	18
1,3-DICHLOROBENZENE	53	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	53	1	0	3	*	3	3	*	3
3,3-DICHLOROBENZIDINE	52	1	0	3	*	3	3	*	3

Table VI-2 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	51	3	0	3	*	3	3	*	3
1,2-TRANS-DICHLOROETHYLENE	51	11	0	0	0	2	2	3	10
2,4-DICHLOROPHENOL	51	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	51	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	51	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	51	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	53	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	52	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	53	0	0	.	*	.	.	*	.
ETHYLBENZENE	52	8	1	1	*	3	3	*	11
FLUORANTHENE	53	1	0	3	*	3	3	*	3
4-CHLOROPHENYL PHENYL ETHER	53	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	53	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	53	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	53	1	0	3	*	3	3	*	3
METHYLENE CHLORIDE (DICHLOROMETHANE)	51	47	41	3	3	895	5743	9692	71000
METHYL CHLORIDE	51	0	0	.	*	.	.	*	.
METHYL BROMIDE	51	0	0	.	*	.	.	*	.
BROMOFORM	51	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	51	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	51	7	7	14	*	17	21	*	37
DICHLORODIFLUOROMETHANE	51	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	51	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	53	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	53	0	0	.	*	.	.	*	.
ISOPHORONE	53	0	0	.	*	.	.	*	.
NAPHTHALENE	53	4	3	3	*	11	10	*	14
NITROBENZENE	53	0	0	.	*	.	.	*	.

Table VI-2 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	51	0	0	.	*	.	.	*	.
4-NITROPHENOL	51	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	51	1	0	3	*	3	3	*	3
4,6-DINITRO-O-CRESOL	51	1	0	3	*	3	3	*	3
N-NITROSODIMETHYLAMINE	53	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	53	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	53	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	51	1	0	3	*	3	3	*	3
PHENOL	51	8	0	3	*	3	3	*	3
BIS(2-ETHYLHEXYL) PHTHALATE	52	36	27	3	3	170	935	1846	11000
BUTYL BENZYL PHTHALATE	53	6	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	51	25	15	3	3	63	244	605	980
DI-N-OCTYL PHTHALATE	53	1	0	3	*	3	3	*	3
DIETHYL PHTHALATE	52	12	3	1	1	3	101	315	790
DIMETHYL PHTHALATE	53	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	51	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	53	2	0	3	*	3	5	*	6
BENZO(B)FLUORANTHENE	53	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	53	2	2	13	*	13	13	*	13
CHRYSENE	51	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	53	0	0	.	*	.	.	*	.
ANTHRACENE	51	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	53	4	2	3	*	3	8	*	13
FLUORENE	53	1	0	1	*	1	1	*	1
PHENANTHRENE	51	1	0	3	*	3	3	*	3
DIBENZO(A,H)ANTHRACENE	53	3	2	10	*	11	11	*	12
INDENO(1,2,3-C,D)PYRENE	53	3	3	10	*	10	11	*	11
PYRENE	53	1	0	2	*	2	2	*	2

Table VI-2 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	51	17	6	1	1	4	12	23	81
TOLUENE	51	22	5	0	0	2	7	20	40
TRICHLOROETHYLENE	51	3	0	1	*	2	2	*	3
VINYL CHLORIDE	51	0	0	.	*	.	.	*	.
ALDRIN	47	2	0	2.24	*	2.24	2.24	*	2.24
DIELDRIN	47	0	0	.	*	.	.	*	.
CHLORDANE	49	0	0	.	*	.	.	*	.
4,4-DDT	47	1	0	2.24	*	2.24	2.24	*	2.24
4,4-DDE	47	0	0	.	*	.	.	*	.
4,4-DDD	47	1	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN-ALPHA	47	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	47	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	49	0	0	.	*	.	.	*	.
ENDRIN	49	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	47	0	0	.	*	.	.	*	.
HEPTACHLOR	47	2	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR EPOXIDE	47	1	0	2.24	*	2.24	2.24	*	2.24
BHC-ALPHA	47	3	0	0.10	*	1.17	1.52	*	2.24
BHC-BETA	47	3	0	0.28	*	1.25	1.58	*	2.24
BHC (LINDANE)-GAMMA	47	2	0	2.24	*	2.24	2.24	*	2.24
BHC-DELTA	47	3	0	0.10	*	1.17	1.52	*	2.24
PCB-1242 (AROCHLOR 1242)	49	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	49	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	49	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	49	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	49	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	49	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	49	0	0	.	*	.	.	*	.

Table VI-2 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	49	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	53	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	46	6	2	3	*	3	13	*	35
BENZO(A)ANTHRACENE/CHRYSENE	14	1	0	3	*	3	3	*	3
BENZO(3,4/K)FLUORANTHENE	12	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	114	44	17	1	1	4	29	92	255
ARSENIC (TOTAL)	114	44	14	2	2	6	12	29	72
BERYLLIUM (TOTAL)	114	7	0	0	*	1	2	*	3
CADMIUM (TOTAL)	114	16	9	3	4	12	12	17	23
CHROMIUM (TOTAL)	114	63	55	6	9	30	46	63	860
COPPER (TOTAL)	114	61	33	3	6	11	15	27	46
CYANIDE (TOTAL)	62	5	0	3	*	4	5	*	7
LEAD (TOTAL)	114	22	13	2	3	21	66	104	620
MERCURY (TOTAL)	114	39	1	0.10	0.30	0.70	1.47	2.51	13.00
NICKEL (TOTAL)	112	25	23	5	15	60	75	138	182
SELENIUM (TOTAL)	114	32	15	1	1	6	22	64	160
SILVER (TOTAL)	114	29	21	2	5	15	16	26	31
THALLIUM (TOTAL)	113	19	5	1	1	2	13	24	137
ZINC (TOTAL)	113	85	79	6	10	40	59	131	382

Table VI-2 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	110	109	32	2500	15925	28507	62200	450000
PH (UNITS)	113	113	3.2	6.6	7.8	7.6	8.4	10.8
IRON (TOTAL)	115	111	21	128	520	1239	3120	11205
MANGANESE (TOTAL)	110	98	11	25	303	922	2020	7167
ASBESTOS(TOTAL-FIBERS/LITER)	24	24	560000	1379E4	8800E5	6766E6	1800E7	5200E7
COD	62	55	40	11600	24350	89569	48000	3260E3
DISSOLVED SOLIDS	45	45	35000	115000	805000	1232E3	2850E3	6600E3
TOTAL VOLATILE SOLIDS	46	46	26000	51200	135000	1689E3	467599	6700E4
VOLATILE SUSPENDED SOLIDS	35	27	1000	1000	4700	13304	15120	200000
SETTLEABLE SOLIDS	66	47	0.0	0.0	0.0	4.9	0.2	200.0
TOTAL ORGANIC CARBON	56	51	260	1051	9000	15366	38940	65000
FREE ACIDITY (CACO3)	2	2	50	*	50	14025	*	28000
MO ALKALINITY (CACO3)	47	47	100	16400	130000	170428	383000	620000
PHENOLICS(4AAP)	61	10	2	2	13	15	20	40
SULFATE	6	6	130000	*	246667	552778	*	1373E3
TOTAL ACIDITY (CACO3)	4	4	3000	*	4000	5500	*	10500
TOTAL SOLIDS	43	43	7000	263000	835000	5895E3	4043E3	1900E5

Table VI-3

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	13	0	0	.	*	.	.	*	.
ACROLEIN	13	0	0	.	*	.	.	*	.
ACRYLONITRILE	13	0	0	.	*	.	.	*	.
BENZENE	13	9	0	1	*	2	3	*	7
BENZIDENE	13	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	13	0	0	.	*	.	.	*	.
CHLOROBENZENE	13	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	13	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	13	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	13	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	13	3	0	1	*	1	2	*	2
HEXACHLOROETHANE	13	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	13	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	13	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	13	0	0	.	*	.	.	*	.
CHLOROETHANE	13	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	13	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	13	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	13	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	13	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	11	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	11	0	0	.	*	.	.	*	.
CHLOROFORM	13	10	6	1	1	14	72	170	442
2-CHLOROPHENOL	11	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	13	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	13	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	13	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	12	0	0	.	*	.	.	*	.

Table VI-3 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	13	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	13	4	0	1	*	1	2	*	2
2,4-DICHLOROPHENOL	11	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	13	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	13	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	11	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	13	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	13	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	13	0	0	.	*	.	.	*	.
ETHYLBENZENE	14	3	0	1	*	1	2	*	3
FLUORANTHENE	13	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	13	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	13	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	13	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	13	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	13	13	12	7	7	2250	3968	9843	13000
METHYL CHLORIDE	13	0	0	.	*	.	.	*	.
METHYL BROMIDE	13	0	0	.	*	.	.	*	.
BROMOFORM	13	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	13	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	13	2	2	14	*	14	26	*	37
DICHLORODIFLUOROMETHANE	13	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	13	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	13	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	13	0	0	.	*	.	.	*	.
ISOPHORONE	13	0	0	.	*	.	.	*	.
NAPHTHALENE	13	2	2	12	*	12	13	*	14
NITROBENZENE	13	0	0	.	*	.	.	*	.

Table VI-3 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	11	0	0	.	*	.	.	*	.
4-NITROPHENOL	11	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	11	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	11	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	13	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	13	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	13	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	11	0	0	.	*	.	.	*	.
PHENOL	11	0	0	.	*	.	.	*	.
BIS(2-ETHYLHEXYL) PHTHALATE	13	11	11	4	4	495	1586	3004	11000
BUTYL BENZYL PHTHALATE	13	1	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	12	8	7	3	*	219	281	*	600
DI-N-OCTYL PHTHALATE	13	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	13	4	1	1	*	1	4	*	13
DIMETHYL PHTHALATE	13	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	11	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	13	2	0	3	*	3	5	*	8
BENZO(B)FLUORANTHENE	13	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	13	2	2	13	*	13	13	*	13
CHRYSENE	11	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	13	0	0	.	*	.	.	*	.
ANTHRACENE	11	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	13	2	2	11	*	11	12	*	13
FLUORENE	13	0	0	.	*	.	.	*	.
PHENANTHRENE	11	1	0	3	*	3	3	*	3
DIBENZO(A,H)ANTHRACENE	13	2	1	10	*	10	11	*	12
INDENO(1,2,3-C,D)PYRENE	13	2	2	11	*	11	11	*	11
PYRENE	13	0	0	.	*	.	.	*	.

Table VI-3 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXICE POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	13	5	3	2	*	9	13	*	31
TOLUENE	13	7	0	0	*	2	3	*	5
TRICHLOROETHYLENE	13	0	0	.	*	.	.	*	.
VINYL CHLORIDE	13	0	0	.	*	.	.	*	.
ALDRIN	9	0	0	.	*	.	.	*	.
DIELDRIN	9	0	0	.	*	.	.	*	.
CHLORDANE	9	0	0	.	*	.	.	*	.
4,4-DDT	9	0	0	.	*	.	.	*	.
4,4-DDE	9	0	0	.	*	.	.	*	.
4,4-DDD	9	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	9	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	9	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	9	0	0	.	*	.	.	*	.
ENDRIN	9	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	9	0	0	.	*	.	.	*	.
HEPTACHLOR	9	0	0	.	*	.	.	*	.
HEPTACHLOR EPOXIDE	9	0	0	.	*	.	.	*	.
BHC-ALPHA	9	1	0	2.24	*	2.24	2.24	*	2.24
BHC-BETA	9	1	0	2.24	*	2.24	2.24	*	2.24
BHC (LINDANE)-GAMMA	9	1	0	2.24	*	2.24	2.24	*	2.24
BHC-DELTA	9	1	0	2.24	*	2.24	2.24	*	2.24
PCB-1242 (AROCHLOR 1242)	9	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	9	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	9	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	9	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	9	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	9	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	9	0	0	.	*	.	.	*	.

Table VI-3 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	9	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	13	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	11	2	2	28	*	28	32	*	35
BENZO(A)ANTHRACENE/CHRYSENE	4	0	0	.	*	.	.	*	.
BENZO(3,4/K)FLUORANTHENE	2	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	23	10	1	2	2	3	5	9	13
ARSENIC (TOTAL)	23	10	7	2	2	13	16	28	37
BERYLLIUM (TOTAL)	23	1	0	3	*	3	3	*	3
CADMIUM (TOTAL)	23	2	2	12	*	12	15	*	18
CHROMIUM (TOTAL)	23	13	12	9	10	27	39	67	126
COPPER (TOTAL)	23	15	9	6	6	12	14	21	27
CYANIDE (TOTAL)	15	1	0	6	*	6	6	*	6
LEAD (TOTAL)	23	5	3	3	*	40	167	*	620
MERCURY (TOTAL)	23	10	0	0.30	0.30	0.90	1.09	1.60	2.50
NICKEL (TOTAL)	23	8	7	5	*	69	82	*	180
SELENIUM (TOTAL)	23	11	7	1	1	12	25	65	77
SILVER (TOTAL)	23	11	9	2	2	11	16	26	30
THALLIUM (TOTAL)	23	3	0	2	*	2	2	*	3
ZINC (TOTAL)	23	19	18	6	16	38	63	142	167

Table VI-3 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	22	21	2700	3865	14000	34194	62300	197850
PH (UNITS)	24	24	3.5	6.1	7.3	7.5	8.6	10.8
IRON (TOTAL)	23	22	63	71	859	1575	4400	6500
MANGANESE (TOTAL)	23	22	22	82	1300	2086	5672	7167
ASBESTOS(TOTAL-FIBERS/LITER)	8	8	560000	*	1300E5	5456E5	*	2100E6
COD	15	10	10200	10200	23667	43637	49400	190000
DISSOLVED SOLIDS	14	14	35000	41400	330000	1223E3	2620E3	6600E3
TOTAL VOLATILE SOLIDS	10	10	30000	30000	135000	218625	430000	530000
VOLATILE SUSPENDED SOLIDS	6	4	1400	*	1400	3500	*	6600
SETTLEABLE SOLIDS	14	9	0.0	*	0.0	0.1	*	0.1
TOTAL ORGANIC CARBON	15	14	260	365	6900	7457	15640	17200
FREE ACIDITY (CACO3)	1	1	28000	*	28000	28000	*	28000
MO ALKALINITY (CACO3)	13	13	100	3670	29000	47238	113400	130000
PHENOLICS(4AAP)	15	2	14	*	14	17	*	20
SULFATE	5	5	130000	*	441667	629333	*	1373E3
TOTAL SOLIDS	10	10	430000	430000	2900E3	3090E3	5000E3	8100E3

Table VI-4

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	30	0	0	.	*	.	.	*	.
ACROLEIN	28	0	0	.	*	.	.	*	.
ACRYLONITRILE	28	0	0	.	*	.	.	*	.
BENZENE	28	9	1	0	*	1	3	*	18
BENZIDENE	30	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	28	0	0	.	*	.	.	*	.
CHLOROBENZENE	27	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	30	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	30	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	28	2	0	1	*	1	1	*	1
1,1,1-TRICHLOROETHANE	28	4	0	1	*	1	2	*	3
HEXACHLOROETHANE	30	1	0	3	*	3	3	*	3
1,1-DICHLOROETHANE	28	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	28	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	28	0	0	.	*	.	.	*	.
CHLOROETHANE	28	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	28	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	30	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	28	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	30	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	30	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	30	0	0	.	*	.	.	*	.
CHLOROFORM	28	21	11	2	3	11	50	121	468
2-CHLOROPHENOL	30	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	30	2	1	3	*	3	11	*	18
1,3-DICHLOROBENZENE	30	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	30	1	0	3	*	3	3	*	3
3,3-DICHLOROBENZIDINE	30	1	0	3	*	3	3	*	3

Table VI-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	28	2	0	3	*	3	3	*	3
1,2-TRANS-DICHLOROETHYLENE	28	3	0	0	*	1	1	*	2
2,4-DICHLOROPHENOL	30	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	28	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	28	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	30	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	30	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	30	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	30	0	0	.	*	.	.	*	.
ETHYLBENZENE	28	4	1	1	*	3	5	*	11
FLUORANTHENE	30	1	0	3	*	3	3	*	3
4-CHLOROPHENYL PHENYL ETHER	30	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	30	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	30	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	30	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	28	25	22	3	3	792	5090	8482	71000
METHYL CHLORIDE	28	0	0	.	*	.	.	*	.
METHYL BROMIDE	28	0	0	.	*	.	.	*	.
BROMOFORM	28	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	28	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	28	4	4	16	*	17	19	*	25
DICHLORODIFLUOROMETHANE	28	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	28	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	30	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	30	0	0	.	*	.	.	*	.
ISOPHORONE	30	0	0	.	*	.	.	*	.
NAPHTHALENE	30	1	1	11	*	11	11	*	11
NITROBENZENE	30	0	0	.	*	.	.	*	.

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	30	0	0	.	*	.	.	*	.
4-NITROPHENOL	30	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	30	1	0	3	*	3	3	*	3
4,6-DINITRO-O-CRESOL	30	1	0	3	*	3	3	*	3
N-NITROSODIMETHYLAMINE	30	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	30	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	30	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	30	1	0	3	*	3	3	*	3
PHENOL	30	5	0	3	*	3	3	*	3
BIS(2-ETHYLHEXYL) PHTHALATE	30	16	12	3	3	170	572	778	4400
BUTYL BENZYL PHTHALATE	30	5	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	30	12	6	3	3	3	280	674	980
DI-N-OCTYL PHTHALATE	30	1	0	3	*	3	3	*	3
DIETHYL PHTHALATE	30	5	1	3	*	3	81	*	390
DIMETHYL PHTHALATE	30	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	30	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	30	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	30	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	30	0	0	.	*	.	.	*	.
CHRYSENE	30	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	30	0	0	.	*	.	.	*	.
ANTHRACENE	30	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	30	2	0	3	*	3	3	*	3
FLUORENE	30	1	0	1	*	1	1	*	1
PHENANTHRENE	30	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	30	1	1	12	*	12	12	*	12
INDENO(1,2,3-C,D)PYRENE	30	1	1	10	*	10	10	*	10
PYRENE	30	1	0	2	*	2	2	*	2

Table VI-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	28	8	2	1	*	4	14	*	81
TOLUENE	28	10	4	0	0	2	12	40	40
TRICHLOROETHYLENE	28	2	0	1	*	1	2	*	3
VINYL CHLORIDE	28	0	0	.	*	.	.	*	.
ALDRIN	28	1	0	2.24	*	2.24	2.24	*	2.24
DIELDRIN	28	0	0	.	*	.	.	*	.
CHLORDANE	30	0	0	.	*	.	.	*	.
4,4-DDT	28	0	0	.	*	.	.	*	.
4,4-DDE	28	0	0	.	*	.	.	*	.
4,4-DDD	28	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	28	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	28	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	30	0	0	.	*	.	.	*	.
ENDRIN	30	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	28	0	0	.	*	.	.	*	.
HEPTACHLOR	28	1	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR EPOXIDE	28	1	0	2.24	*	2.24	2.24	*	2.24
BHC-ALPHA	28	1	0	0.10	*	0.10	0.10	*	0.10
BHC-BETA	28	1	0	0.26	*	0.26	0.26	*	0.26
BHC (LINDANE)-GAMMA	28	1	0	2.24	*	2.24	2.24	*	2.24
BHC-DELTA	28	1	0	0.10	*	0.10	0.10	*	0.10
PCB-1242 (AROCHLOR 1242)	30	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	30	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	30	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	30	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	30	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	30	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	30	0	0	.	*	.	.	*	.

Table VI-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	30	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	30	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	29	3	0	3	*	3	3	*	3
BENZO(A)ANTHRACENE/CHRYSENE	8	1	0	3	*	3	3	*	3
BENZO(3,4/K)FLUORANTHENE	8	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	57	18	5	1	1	3	6	15	18
ARSENIC (TOTAL)	57	25	4	2	2	6	9	12	72
BERYLLIUM (TOTAL)	57	1	0	0	*	0	0	*	0
CADMIUM (TOTAL)	57	7	5	5	*	14	14	*	23
CHROMIUM (TOTAL)	57	32	28	8	10	34	63	64	860
COPPER (TOTAL)	57	24	9	3	5	9	13	27	40
CYANIDE (TOTAL)	37	4	0	3	*	3	4	*	7
LEAD (TOTAL)	57	14	8	2	2	20	36	81	109
MERCURY (TOTAL)	57	25	1	0.10	0.30	0.65	1.63	2.20	13.00
NICKEL (TOTAL)	57	9	8	10	*	55	62	*	146
SELENIUM (TOTAL)	57	12	3	1	1	3	19	24	160
SILVER (TOTAL)	57	9	9	13	*	17	19	*	25
THALLIUM (TOTAL)	56	9	2	1	*	2	5	*	23
ZINC (TOTAL)	56	37	33	7	10	43	52	101	188

Table VI-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	58	58	32	2000	12500	29542	70827	450000
PH (UNITS)	58	58	3.2	7.1	7.8	7.7	8.4	9.4
IRON (TOTAL)	57	54	21	132	390	892	2589	5100
MANGANESE (TOTAL)	58	47	11	18	170	381	1100	2800
ASBESTOS(TOTAL-FIBERS/LITER)	15	15	3300E4	3300E4	2050E8	1053E7	2950E7	5200E7
COD	37	35	40	9700	22413	117475	45500	3280E3
DISSOLVED SOLIDS	23	23	88000	205000	880000	1198E3	2780E3	3800E3
TOTAL VOLATILE SOLIDS	29	29	44000	65200	135000	2571E3	608426	8700E4
VOLATILE SUSPENDED SOLIDS	24	18	1000	1000	4000	16133	12880	200000
SETTLEABLE SOLIDS	32	28	0.0	0.0	0.0	8.2	0.4	200.0
TOTAL ORGANIC CARBON	34	31	1000	3087	9383	19595	47820	85000
FREE ACIDITY (CACO3)	1	1	50	*	50	50	*	50
MO ALKALINITY (CACO3)	23	23	23000	84900	245000	280783	494000	820000
PHENOLICS(4AAP)	38	5	2	*	9	16	*	40
TOTAL ACIDITY (CACO3)	1	1	10500	*	10500	10500	*	10500
TOTAL SOLIDS	27	27	148000	312000	820000	8031E3	2480E3	1900E5

Table VI-5

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	7	0	0	.	*	.	.	*	.
ACROLEIN	7	0	0	.	*	.	.	*	.
ACRYLONITRILE	7	0	0	.	*	.	.	*	.
BENZENE	7	2	1	1	*	1	7	*	12
BENZIDENE	7	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	7	0	0	.	*	.	.	*	.
CHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	7	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	7	3	0	2	*	2	2	*	3
HEXACHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	7	1	0	3	*	3	3	*	3
CHLOROETHANE	7	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	7	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	7	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	7	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	7	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	7	0	0	.	*	.	.	*	.
CHLOROFORM	7	6	3	3	*	3	21	*	78
2-CHLOROPHENOL	7	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	7	0	0	.	*	.	.	*	.

Table VI-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	7	1	0	3	*	3	3	*	3
1,2-TRANS-DICHLOROETHYLENE	7	3	0	1	*	2	5	*	10
2,4-DICHLOROPHENOL	7	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	7	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	7	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	7	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	7	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	6	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	7	0	0	.	*	.	.	*	.
ETHYLBENZENE	7	1	0	3	*	3	3	*	3
FLUORANTHENE	7	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	7	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	7	1	0	3	*	3	3	*	3
METHYLENE CHLORIDE (DICHLOROMETHANE)	7	8	4	3	*	463	3998	*	20000
METHYL CHLORIDE	7	0	0	.	*	.	.	*	.
METHYL BROMIDE	7	0	0	.	*	.	.	*	.
BROMOFORM	7	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	7	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	7	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	7	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	7	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	7	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	7	0	0	.	*	.	.	*	.
ISOPHORONE	7	0	0	.	*	.	.	*	.
NAPHTHALENE	7	1	0	3	*	3	3	*	3
NITROBENZENE	7	0	0	.	*	.	.	*	.

Table VI-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	7	0	0	.	*	.	.	*	.
4-NITROPHENOL	7	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	7	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	7	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	7	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	7	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	7	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	7	0	0	.	*	.	.	*	.
PHENOL	7	3	0	3	*	3	3	*	3
BIS(2-ETHYLHEXYL) PHTHALATE	6	6	3	3	*	3	160	*	510
BUTYL BENZYL PHTHALATE	7	0	0	.	*	.	.	*	.
DI-N-BUTYL PHTHALATE	6	3	1	3	*	3	92	*	270
DI-N-OCTYL PHTHALATE	7	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	6	3	1	3	*	3	265	*	790
DIMETHYL PHTHALATE	7	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	7	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	7	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	7	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	7	0	0	.	*	.	.	*	.
CHRYSENE	7	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	7	0	0	.	*	.	.	*	.
ANTHRACENE	7	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	7	0	0	.	*	.	.	*	.
FLUORENE	7	0	0	.	*	.	.	*	.
PHENANTHRENE	7	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	7	0	0	.	*	.	.	*	.
INDENO(1,2,3-C,D)PYRENE	7	0	0	.	*	.	.	*	.
PYRENE	7	0	0	.	*	.	.	*	.

Table VI-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	7	3	1	3	*	4	9	*	20
TOLUENE	7	3	1	0	*	3	4	*	7
TRICHLOROETHYLENE	7	1	0	3	*	3	3	*	3
VINYL CHLORIDE	7	0	0	.	*	.	.	*	.
ALDRIN	7	0	0	.	*	.	.	*	.
DIELDRIN	7	0	0	.	*	.	.	*	.
CHLORDANE	7	0	0	.	*	.	.	*	.
4,4-DDT	7	0	0	.	*	.	.	*	.
4,4-DDE	7	0	0	.	*	.	.	*	.
4,4-DDD	7	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	7	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	7	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	7	0	0	.	*	.	.	*	.
ENDRIN	7	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	7	0	0	.	*	.	.	*	.
HEPTACHLOR	7	0	0	.	*	.	.	*	.
HEPTACHLOR EPOXIDE	7	0	0	.	*	.	.	*	.
BHC-ALPHA	7	0	0	.	*	.	.	*	.
BHC-BETA	7	0	0	.	*	.	.	*	.
BHC (LINDANE)-GAMMA	7	0	0	.	*	.	.	*	.
BHC-DELTA	7	0	0	.	*	.	.	*	.
PCB-1242 (AROCHLOR 1242)	7	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	7	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	7	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	7	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	7	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	7	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	7	0	0	.	*	.	.	*	.

Table VI-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	7	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	7	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	3	1	0	3	*	3	3	*	3
BENZO(A)ANTHRACENE/CHRYSENE	1	0	0	.	*	.	.	*	.
BENZO(3,4/K)FLUORANTHENE	1	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	9	3	0	1	*	1	2	*	3
ARSENIC (TOTAL)	9	4	1	2	*	3	10	*	30
BERYLLIUM (TOTAL)	9	0	0	.	*	.	.	*	.
CADMIUM (TOTAL)	9	1	0	3	*	3	3	*	3
CHROMIUM (TOTAL)	9	4	4	24	*	24	31	*	41
COPPER (TOTAL)	9	6	4	5	*	13	20	*	46
CYANIDE (TOTAL)	7	0	0	.	*	.	.	*	.
LEAD (TOTAL)	9	2	2	57	*	57	62	*	67
MERCURY (TOTAL)	9	1	0	0.30	*	0.30	0.30	*	0.30
NICKEL (TOTAL)	9	2	2	20	*	20	35	*	50
SELENIUM (TOTAL)	9	4	3	5	*	7	20	*	50
SILVER (TOTAL)	9	2	1	6	*	6	15	*	24
THALLIUM (TOTAL)	9	4	0	1	*	2	3	*	7
ZINC (TOTAL)	9	6	6	39	*	40	70	*	200

Table VI-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	8	8	2500	*	11800	14044	*	29500
PH (UNITS)	9	9	6.2	*	7.1	7.4	*	9.1
IRON (TOTAL)	9	9	98	*	388	868	*	4400
MANGANESE (TOTAL)	6	5	25	*	66	247	*	700
ASBESTOS(TOTAL-FIBERS/LITER)	1	1	1400E5	*	1400E5	1400E5	*	1400E5
COD	7	7	20350	*	35200	44984	*	113000
DISSOLVED SOLIDS	2	2	560000	*	560000	1020E3	*	1480E3
TOTAL VOLATILE SOLIDS	4	4	94000	*	140000	210438	*	420000
VOLATILE SUSPENDED SOLIDS	3	3	3600	*	4200	10133	*	22000
SETTLEABLE SOLIDS	2	2	0.0	*	0.0	0.1	*	0.1
TOTAL ORGANIC CARBON	4	4	5875	*	11600	14868	*	25000
MO ALKALINITY (CACO3)	5	5	19000	*	40750	61900	*	118500
PHENOLICS(4AAP)	7	3	10	*	10	12	*	15
TOTAL ACIDITY (CACO3)	3	3	3000	*	3500	3833	*	4500
TOTAL SOLIDS	4	4	7000	*	530000	1334E3	*	3700E3

Table VI-6

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	3	0	0	.	*	.	.	*	.
ACROLEIN	3	0	0	.	*	.	.	*	.
ACRYLONITRI'	3	0	0	.	*	.	.	*	.
BENZENE	3	1	0	6	*	6	6	*	6
BENZIDENE	3	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	3	0	0	.	*	.	.	*	.
CHLOROBENZENE	3	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	3	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	3	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	3	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	3	1	0	2	*	2	2	*	2
HEXACHLOROETHANE	3	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	3	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	3	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	3	0	0	.	*	.	.	*	.
CHLOROETHANE	3	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	3	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	3	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	3	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	3	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	3	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	3	0	0	.	*	.	.	*	.
CHLOROFORM	3	3	2	3	*	11	166	*	476
2-CHLOROPHENOL	3	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	3	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	3	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	3	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	3	0	0	.	*	.	.	*	.

Table VI-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	3	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	3	1	0	2	*	2	2	*	2
2,4-DICHLOROPHENOL	3	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	3	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	3	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	3	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	3	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	3	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	3	0	0	.	*	.	.	*	.
ETHYLBENZENE	3	0	0	.	*	.	.	*	.
FLUORANTHENE	3	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	3	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	3	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	3	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	3	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	3	3	3	7	*	553	22369	*	66000
METHYL CHLORIDE	3	0	0	.	*	.	.	*	.
METHYL BROMIDE	3	0	0	.	*	.	.	*	.
BROMOFORM	3	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	3	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	3	1	1	22	*	22	22	*	22
DICHLORODIFLUOROMETHANE	3	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	3	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	3	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	3	0	0	.	*	.	.	*	.
ISOPHORONE	3	0	0	.	*	.	.	*	.
NAPHTHALENE	3	0	0	.	*	.	.	*	.
NITROBENZENE	3	0	0	.	*	.	.	*	.

Table VI-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	3	0	0	.	*	.	.	*	.
4-NITROPHENOL	3	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	3	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	3	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	3	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	3	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	3	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	3	0	0	.	*	.	.	*	.
PHENOL	3	0	0	.	*	.	.	*	.
BIS(2-ETHYLHEXYL) PHTHALATE	3	3	1	3	*	7	2038	*	6100
BUTYL BENZYL PHTHALATE	3	0	0	.	*	.	.	*	.
DI-N-BUTYL PHTHALATE	3	2	1	3	*	3	107	*	210
DI-N-OCTYL PHTHALATE	3	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	3	0	0	.	*	.	.	*	.
DIMETHYL PHTHALATE	3	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	3	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	3	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	3	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	3	0	0	.	*	.	.	*	.
CHRYSENE	3	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	3	0	0	.	*	.	.	*	.
ANTHRACENE	3	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	3	0	0	.	*	.	.	*	.
FLUORENE	3	0	0	.	*	.	.	*	.
PHENANTHRENE	3	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	3	0	0	.	*	.	.	*	.
INDENO(1,2,3-C,D)PYRENE	3	0	0	.	*	.	.	*	.
PYRENE	3	0	0	.	*	.	.	*	.

Table VI-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	3	1	0	1	*	1	1	*	1
TOLUENE	3	2	0	2	*	2	3	*	3
TRICHLOROETHYLENE	3	0	0	.	*	.	.	*	.
VINYL CHLORIDE	3	0	0	.	*	.	.	*	.
ALDRIN	3	1	0	2.24	*	2.24	2.24	*	2.24
DIELDRIN	3	0	0	.	*	.	.	*	.
CHLORDANE	3	0	0	.	*	.	.	*	.
4,4-DDT	3	1	0	2.24	*	2.24	2.24	*	2.24
4,4-DDE	3	0	0	.	*	.	.	*	.
4,4-DDD	3	1	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN-ALPHA	3	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	3	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	3	0	0	.	*	.	.	*	.
ENDRIN	3	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	3	0	0	.	*	.	.	*	.
HEPTACHLOR	3	1	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR EPOXIDE	3	0	0	.	*	.	.	*	.
BHC-ALPHA	3	1	0	2.24	*	2.24	2.24	*	2.24
BHC-BETA	3	1	0	2.24	*	2.24	2.24	*	2.24
BHC (LINDANE)-GAMMA	3	0	0	.	*	.	.	*	.
BHC-DELTA	3	1	0	2.24	*	2.24	2.24	*	2.24
PCB-1242 (AROCHLOR 1242)	3	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	3	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	3	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	3	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	3	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	3	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	3	0	0	.	*	.	.	*	.

Table VI-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	3	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	3	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	3	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE/CHRYSENE	1	0	0	.	*	.	.	*	.
BENZO(3,4/K)FLUORANTHENE	1	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	8	2	0	2	*	2	3	*	4
ARSENIC (TOTAL)	8	3	0	2	*	3	3	*	4
BERYLLIUM (TOTAL)	8	0	0	.	*	.	.	*	.
CADMIUM (TOTAL)	8	2	2	15	*	15	16	*	17
CHROMIUM (TOTAL)	8	5	5	14	*	27	30	*	49
COPPER (TOTAL)	8	5	3	6	*	11	16	*	32
CYANIDE (TOTAL)	3	0	0	.	*	.	.	*	.
LEAD (TOTAL)	8	1	0	3	*	3	3	*	3
MERCURY (TOTAL)	8	3	0	0.40	*	0.55	1.80	*	4.30
NICKEL (TOTAL)	8	3	3	59	*	59	83	*	130
SELENIUM (TOTAL)	8	3	0	1	*	2	5	*	9
SILVER (TOTAL)	8	3	2	8	*	17	22	*	31
THALLIUM (TOTAL)	8	0	0	.	*	.	.	*	.
ZINC (TOTAL)	8	6	6	19	*	38	56	*	150

Table VI-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	MIN	DETECTED CONCENTRATIONS IN UG/L 10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	6	6	6000	*	18400	24897	*	82000
PH (UNITS)	6	6	7.2	*	7.6	8.0	*	9.7
IRON (TOTAL)	6	8	205	*	620	1760	*	9500
MANGANESE (TOTAL)	8	7	27	*	348	1775	*	6300
COD	3	3	15500	*	17217	21178	*	29100
DISSOLVED SOLIDS	3	3	1550E3	*	1625E3	1717E3	*	1900E3
TOTAL VOLATILE SOLIDS	3	3	26000	*	31000	40111	*	58333
VOLATILE SUSPENDED SOLIDS	2	2	4800	*	4800	12200	*	19600
SETTLEABLE SOLIDS	4	4	0.0	*	0.0	0.1	*	0.1
TOTAL ORGANIC CARBON	3	2	5500	*	5500	6567	*	7633
MO ALKALINITY (CACO3)	3	3	25000	*	34500	64167	*	123500
PHENOLICS(4AAP)	3	0	.	*	.	.	*	.
SULFATE	1	1	170000	*	170000	170000	*	170000
TOTAL SOLIDS	2	2	180000	*	180000	220000	*	260000

Table VI-7

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY AREAS UNDER RECLAMATION
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	14	11	11	52	53	78	100	116	255
ARSENIC (TOTAL)	14	2	2	42	*	42	49	*	55
BERYLLIUM (TOTAL)	14	5	0	1	*	1	2	*	3
CADMIUM (TOTAL)	14	3	0	6	*	7	7	*	8
CHROMIUM (TOTAL)	14	8	5	6	*	9	12	*	24
COPPER (TOTAL)	14	11	8	5	5	15	17	26	41
LEAD (TOTAL)	14	0	0	.	*	.	.	*	.
MERCURY (TOTAL)	14	0	0		*	.	.	*	.
NICKEL (TOTAL)	14	3	3	71	*	82	115	*	182
SELENIUM (TOTAL)	14	2	2	42	*	42	60	*	77
SILVER (TOTAL)	14	4	0	6	*	6	6	*	7
THALLIUM (TOTAL)	14	3	3	12	*	23	61	*	137
ZINC (TOTAL)	14	14	14	8	9	33	71	187	382

Table VI-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY AREAS UNDER RECLAMATION
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	MIN	DETECTED CONCENTRATIONS IN UG/L				
				10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	15	15	10400	11004	21675	29845	46125	81869
PH (UNITS)	15	15	5.5	6.0	7.5	7.4	7.9	8.0
IRON (TOTAL)	15	15	302	315	814	2101	5457	11205
MANGANESE (TOTAL)	14	14	77	84	235	828	911	6940
SETTLEABLE SOLIDS	12	5	0.0	*	0.1	3.1	*	14.8

Table VI-8

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/1	Detected in Amounts too Small to Be Effectively Reduced
acenaphthene	x			
acrolein	x			
acrylonitrile	x			
benzene		x		
benzidine	x			
carbon tetrachloride (tetrachloromethane)	x			
chlorobenzene	x			
1,2,4-trichlorobenzene	x			
hexachlorobenzene	x			
1,2-dichloroethane			x	
1,1,1-trichloroethane				x
hexachloroethane			x	
1,1-dichloroethane	x			
1,1,2-trichloroethane	x			
1,1,2,2-tetrachloroethane			x	
chloroethane	x			
bis(chloromethyl)ether	x			
bis(2-chloroethyl)ether	x			

Table VI-8 (Continued)

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/1	Detected in Amounts too Small to Be Effectively Reduced
2-chloroethyl vinyl ether (mixed)	x			
2-chloronaphthalene	x			
2,4,6-trichlorophenol	x			
parachlorometa cresol	x			
chloroform (trichloromethane)		x		
2-chlorophenol	x			
1,2-dichlorobenzene				x
1,3-dichlorobenzene	x			
1,4-dichlorobenzene			x	
3,3'-dichlorobenzidine			x	
1,1-dichloroethylene				x
1,2-trans-dichloroethylene				x
2,4-dichlorophenol	x			
1,2-dichloropropane	x			
1,2-dichloropropylene (1,3-dichloropropene)	x			
2,4-dimethylphenol	x			

Table VI-8 (Continued)

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/l	Detected in Amounts too Small to Be Effectively Reduced
2,4-dinitrotoluene	x			
2,6-dinitrotoluene	x			
1,2-diphenylhydrazine	x			
ethylbenzene				x
fluoranthene			x	
4-chlorophenyl phenyl ether	x			
4-bromophenyl phenyl ether	x			
bis(2-chloroisopropyl) ether	x			
bis(2-chloroethoxy) methane			x	
methylene chloride (dichloromethane)		x		
methyl chloride (chloromethane)	x			
methyl bromide (bromomethane)	x			
bromoform	x			

Table VI-8 (Continued)

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/l	Detected in Amounts too Small to Be Effectively Reduced
dichlorobromomethane	x			
trichlorofluoromethane				x
dichlorodifluoromethane	x			
chlorodibromomethane	x			
hexachlorobutadiene	x			
hexachlorocyclopentadiene	x			
isophorone	x			
naphthalene				x
nitrobenzene	x			
2-nitrophenol	x			
4-nitrophenol	x			
2,4-dinitrophenol			x	
4,6-dinitro-o-cresol			x	
N-nitrosodimethylamine	x			
N-nitrosodiphenylamine	x			
N-nitrosodi-n-propylamine	x			
pentachlorophenol			x	
phenol		x		

Table VI-8 (Continued)

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/1	Detected in Amounts too Small to Be Effectively Reduced
bis(2-ethylhexyl) phthalate		x		
butyl benzyl phthalate		x		
di-n-butyl phthalate		x		
di-n-octyl phthalate			x	
diethyl phthalate		x		
dimethyl phthalate	x			
benzo(a)anthracene (1,2-benzanthracene)			x	
benzo(a)pyrene(3,4-benzopyrene)	x			
3,4-benzofluoranthene	x			
benzo(k)fluoranthene (11,12-benzofluoranthene)	x			
chrysene			x	
acenaphthylene	x			
anthracene			x	
benzo(g,h,i)perylene (1,12-benzoperylene)			x	

Table VI-8 (Continued)

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/1	Detected in Amounts too Small to Be Effectively Reduced
fluorene			x	
phenanthrene			x	
dibenzo(a,h)anthracene (1,2,5,6-dibenzanthracene)				x
indeno(1,2,3-c,d)pyrene (phenylenepyrene)				x
pyrene			x	
tetrachloroethylene		x		
toluene		x		
vinyl chloride (chloroethylene)	x			
trichloroethylene				x
aldrin			x	
dieldrin	x			
chlordane (technical (mixture and metabolites)	x			
4,4'-DDT			x	
4,4'-DDE (p,p'-DDX)	x			
4,4'-DDD (p,p'-TDE)			x	
-endosulfan-Alpha	x			

Table VI-8 (Continued)

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/1	Detected in Amounts too Small to Be Effectively Reduced
-endosulfan-Beta	x			
endosulfan sulfate	x			
endrin	x			
endrin aldehyde	x			
heptachlor			x	
heptachlor epoxide			x	
-BHC-Alpha				x
-BHC-Beta				x
-BHC-(lindane)-Gamma				x
-BHC-Delta				x
PCB 1242 (Arochlor 1242)	x			
PCB-1254 (Arochlor 1254)	x			
PCB-1221 (Arochlor 1221)	x			
PCB-1232 (Arochlor 1232)	x			
PCB-1248 (Arochlor 1248)	x			
PCB-1260 (Arochlor 1260)	x			
PCB-1016 (Arochlor 1016)	x			
toxaphene	x			
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)	x			

Table VI-9

PRIORITY ORGANICS NOT DETECTED IN TREATED EFFLUENTS OF SCREENING AND VERIFICATION SAMPLES

1. acenaphthene
2. acrolein
3. acrylonitrile
4. benzidine
5. carbon tetrachloride (tetrachloromethane)
6. chlorobenzene
7. 1,2,4-trichlorobenzene
8. hexachlorobenzene
9. 1,1-dichloroethane
10. 1,1,2-trichloroethane
11. chloroethane
12. bis(chloromethyl) ether
13. bis(2-chloroethyl) ether
14. 2-chloroethyl vinyl ether (mixed)
15. 2-chloronaphthalene
16. 2,4,6-trichlorophenol
17. parachlorometa cresol
18. 2-chlorophenol
19. 1,3-dichlorobenzene
20. 2,4-dichlorophenol
21. 1,2-dichloropropane
22. 1,2-dichloropropylene (1,3-dichloropropene)
23. 2,4-dimethylphenol
24. 2,4-dinitrotoluene
25. 2,6-dinitrotoluene
26. 1,2-diphenylhydrazine
27. bis(2-chloroisopropyl) ether
28. 4-chlorophenyl phenyl ether

Table VI-9 (Continued)

PRIORITY ORGANICS NOT DETECTED IN TREATED EFFLUENTS OF SCREENING AND VERIFICATION SAMPLES

29. 4-bromophenyl phenyl ether
30. methyl chloride (chloromethane)
31. methyl bromide (bromomethane)
32. bromoform (tribromomethane)
33. dichlorobromomethane
34. dichlorodifluoromethane
35. chlorodibromomethane
36. hexachlorobutadiene
37. hexachlorocyclopentadiene
38. isophorone
39. nitrobenzene
40. 2-nitrophenol
41. 4-nitrophenol
42. N-nitrosodimethylamine
43. N-nitrosodiphenylamine
44. N-nitrosodi-n-propylamine
45. dimethyl phthalate
46. benzo(a)pyrene
47. 3,4-benzofluoranthene
48. benzo(k)fluoranthane(11,12-benzofluoranthene)
49. acenaphthylene
50. vinyl chloride (chloroethylene)
51. dieldrin

Table VI-9 (Continued)

PRIORITY ORGANICS NOT DETECTED IN TREATED EFFLUENTS OF SCREENING AND VERIFICATION SAMPLES

52. chlordane (technical mixture and metabolites)
53. 4,4'-DDE (p,p'-DDX)
54. α-endosulfan-Alpha
55. β-endosulfan-Beta
56. endosulfan sulfate
57. endrin
58. endrin aldehyde
59. PCB 1242 (Arochlor 1242)
60. PCB 1254 (Arochlor 1254)
61. PCB 1221 (Arochlor 1221)
62. PCB 1232 (Arochlor 1232)
63. PCB 1248 (Arochlor 1248)
64. PCB 1260 (Arochlor 1260)
65. PCB 1016 (Arochlor 1016)
66. toxaphene
67. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

Table VI-10

PRIORITY ORGANICS DETECTED BUT PRESENT DUE TO CONTAMINATION OF SOURCES OTHER THAN THOSE SAMPLES SCREENING AND VERIFICATION SAMPLES

1. benzene
2. chloroform
3. methylene chloride
4. phenol
5. bis(2-ethylhexyl)phthalate
6. butyl benzyl phthalate
7. di-n-butyl phthalate
8. diethyl phthalate
9. tetrachloroethylene
10. toluene

Table VI-11

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	44	0	0	.	*	.	.	*	.
ACROLEIN	10	0	0	.	*	.	.	*	.
ACRYLONITRILE	10	0	0	.	*	.	.	*	.
BENZENE	10	5	5	21	*	27	52	*	155
BENZIDENE	44	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	10	0	0	.	*	.	.	*	.
CHLOROBENZENE	10	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	44	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	44	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	10	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	10	1	0	3	*	3	3	*	3
HEXACHLOROETHANE	44	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	10	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	10	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	10	0	0	.	*	.	.	*	.
CHLOROETHANE	10	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	28	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	44	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	10	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	44	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	44	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	44	0	0	.	*	.	.	*	.
CHLOROFORM	10	2	1	3	*	3	25	*	47
2-CHLOROPHENOL	44	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	44	2	0	3	*	3	3	*	3
1,3-DICHLOROBENZENE	43	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	43	3	0	1	*	2	2	*	3
3,3-DICHLOROBENZIDINE	44	0	0	.	*	.	.	*	.

Table VI-11 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	10	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	10	0	0	.	*	.	.	*	.
2,4-DICHLOROPHENOL	44	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	10	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	10	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	44	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	44	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	44	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	44	0	0	.	*	.	.	*	.
ETHYLBENZENE	10	0	0	.	*	.	.	*	.
FLUORANTHENE	44	1	0	3	*	3	3	*	3
4-CHLOROPHENYL PHENYL ETHER	44	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	44	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	44	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	44	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	10	9	7	3	*	282	389	*	880
METHYL CHLORIDE	10	0	0	.	*	.	.	*	.
METHYL BROMIDE	10	0	0	.	*	.	.	*	.
BROMOFORM	10	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	10	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	10	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	10	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	10	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	44	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	44	0	0	.	*	.	.	*	.
ISOPHORONE	44	0	0	.	*	.	.	*	.
NAPHTHALENE	44	1	0	3	*	3	3	*	3
NITROBENZENE	44	0	0	.	*	.	.	*	.

Table VI-11 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	44	0	0	.	*	.	.	*	.
4-NITROPHENOL	44	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	44	1	0	4	*	4	4	*	4
4,6-DINITRO-O-CRESOL	44	1	0	6	*	6	6	*	6
N-NITROSODIMETHYLAMINE	44	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	44	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	44	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	44	0	0	.	*	.	.	*	.
PHENOL	44	2	0	3	*	3	3	*	3
BIS(2-ETHYLHEXYL) PHTHALATE	44	19	14	3	3	215	453	1210	1600
BUTYL BENZYL PHTHALATE	44	2	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	44	13	7	1	1	9	275	880	1100
DI-N-OCTYL PHTHALATE	44	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	44	5	0	1	*	2	2	*	3
DIMETHYL PHTHALATE	44	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	44	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	44	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	44	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	44	0	0	.	*	.	.	*	.
CHRYSENE	44	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	44	0	0	.	*	.	.	*	.
ANTHRACENE	29	1	0	3	*	3	3	*	3
BENZO(G,H,I)PERYLENE	44	1	0	3	*	3	3	*	3
FLUORENE	44	0	0	.	*	.	.	*	.
PHENANTHRENE	29	1	0	3	*	3	3	*	3
DIBENZO(A,H)ANTHRACENE	44	1	0	3	*	3	3	*	3
INDENO(1,2,3-C,D)PYRENE	44	1	0	3	*	3	3	*	3
PYRENE	44	1	0	3	*	3	3	*	3

Table VI-11 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	10	0	0	.	*	.	.	*	.
TOLUENE	10	6	5	3	*	25	41	*	146
TRICHLOROETHYLENE	10	1	0	3	*	3	3	*	3
VINYL CHLORIDE	10	0	0	.	*	.	.	*	.
ALDRIN	37	2	0	3.16	*	3.16	3.16	*	3.16
DIELDRIN	37	1	0	3.16	*	3.16	3.16	*	3.16
CHLORDANE	37	0	0	.	*	.	.	*	.
4,4-DDT	37	0	0	.	*	.	.	*	.
4,4-DDE	37	1	0	3.16	*	3.16	3.16	*	3.16
4,4-DDD	37	1	0	3.16	*	3.16	3.16	*	3.16
ENDOSULFAN-ALPHA	37	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	37	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	37	0	0	.	*	.	.	*	.
ENDRIN	37	1	0	3.16	*	3.16	3.16	*	3.16
ENDRIN ALDEHYDE	37	0	0	.	*	.	.	*	.
HEPTACHLOR	37	1	0	3.16	*	3.16	3.16	*	3.16
HEPTACHLOR EPOXIDE	37	2	0	3.16	*	3.16	3.16	*	3.16
BHC-ALPHA	37	2	0	3.16	*	3.16	3.16	*	3.16
BHC-BETA	37	0	0	.	*	.	.	*	.
BHC (LINDANE)-GAMMA	37	1	0	3.16	*	3.16	3.16	*	3.16
BHC-DELTA	37	2	0	3.16	*	3.16	3.16	*	3.16
PCB-1242 (AROCHLOR 1242)	37	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	37	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	37	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	37	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	37	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	37	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	37	0	0	.	*	.	.	*	.

Table VI-11 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	37	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	27	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	20	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	19	2	0	1	*	1	1	*	1
ARSENIC (TOTAL)	19	10	0	1	1	2	2	3	5
BERYLLIUM (TOTAL)	20	0	0	.	*	.	.	*	.
CADMIUM (TOTAL)	20	1	1	20	*	20	20	*	20
CHROMIUM (TOTAL)	20	1	1	30	*	30	30	*	30
COPPER (TOTAL)	20	9	4	5	*	8	17	*	58
LEAD (TOTAL)	20	5	5	86	*	100	102	*	115
MERCURY (TOTAL)	20	17	0	0.10	0.10	0.35	0.99	3.18	3.90
NICKEL (TOTAL)	20	2	2	50	*	50	50	*	50
SELENIUM (TOTAL)	20	8	0	0	*	2	2	*	2
SILVER (TOTAL)	20	0	0	.	*	.	.	*	.
THALLIUM (TOTAL)	20	3	0	1	*	1	1	*	1
ZINC (TOTAL)	20	10	10	27	27	38	108	300	380

Table VI-11 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECTS	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
IRON (TOTAL)	20	18	43	51	116	4036	4422	50000
MANGANESE (TOTAL)	20	6	10	*	15	46	*	190
PHENOLICS(4AAP)	1	0	.	*	.	.	*	.

Table VI-12

WASTEWATER CHARACTERIZATION SUMMARY
PLANT BLANKS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	21	0	0	.	*	.	.	*	.
ACROLEIN	11	0	0	.	*	.	.	*	.
ACRYLONITRILE	11	0	0	.	*	.	.	*	.
BENZENE	11	9	3	1	*	3	18	*	110
BENZIDENE	21	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	11	0	0	.	*	.	.	*	.
CHLOROBENZENE	11	2	0	3	*	3	3	*	3
1,2,3-TRICHLOROBENZENE	21	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	21	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	11	2	0	1	*	1	2	*	3
1,1,1-TRICHLOROETHANE	11	2	0	1	*	1	1	*	2
HEXACHLOROETHANE	21	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	11	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	11	1	0	3	*	3	3	*	3
1,1,2,2-TETRACHLOROETHANE	11	1	0	3	*	3	3	*	3
CHLOROETHANE	11	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	10	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	21	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	11	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	21	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	21	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	21	0	0	.	*	.	.	*	.
CHLOROFORM	11	11	6	3	3	11	25	52	130
2-CHLOROPHENOL	21	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	21	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	21	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	21	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	21	0	0	.	*	.	.	*	.

Table VI-12 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
PLANT BLANKS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	11	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	11	2	0	1	*	1	2	*	2
2,4-DICHLOROPHENOL	21	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	11	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	11	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	21	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	21	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	21	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	21	0	0	.	*	.	.	*	.
ETHYLBENZENE	11	4	1	1	*	2	6	*	20
FLUORANTHENE	21	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	21	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	21	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	21	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	21	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	11	10	9	3	3	2500	5321	11000	23000
METHYL CHLORIDE	11	0	0	.	*	.	.	*	.
METHYL BROMIDE	11	0	0	.	*	.	.	*	.
BROMOFORM	11	1	0	3	*	3	3	*	3
DICHLOROBROMOMETHANE	11	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	11	8	6	13	*	25	29	*	50
DICHLORODIFLUOROMETHANE	11	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	11	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	21	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	21	0	0	.	*	.	.	*	.
ISOPHORONE	21	0	0	.	*	.	.	*	.
NAPHTHALENE	21	0	0	.	*	.	.	*	.
NITROBENZENE	21	0	0	.	*	.	.	*	.

Table VI-12 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
PLANT BLANKS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	21	0	0	.	*	.	.	*	.
4-NITROPHENOL	21	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	21	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	21	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	21	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	21	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	21	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	21	0	0	.	*	.	.	*	.
PHENOL	21	0	0	.	*	.	.	*	.
BIS(2-ETHYLHEXYL) PHTHALATE	21	4	4	16	*	840	989	*	1600
BUTYL BENZYL PHTHALATE	21	0	0	.	*	.	.	*	.
DI-N-BUTYL PHTHALATE	21	1	1	220	*	220	220	*	220
DI-N-OCTYL PHTHALATE	21	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	21	0	0	.	*	.	.	*	.
DIMETHYL PHTHALATE	21	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	21	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	21	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	21	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	21	0	0	.	*	.	.	*	.
CHRYSENE	21	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	21	0	0	.	*	.	.	*	.
ANTHRACENE	21	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	21	0	0	.	*	.	.	*	.
FLUORENE	21	0	0	.	*	.	.	*	.
PHENANTHRENE	21	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	21	0	0	.	*	.	.	*	.
INDENO(1,2;3-C,D)PYRENE	21	0	0	.	*	.	.	*	.
PYRENE	21	0	0	.	*	.	.	*	.

Table VI-12 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
PLANT BLANKS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	11	8	3	1	*	8	15	*	40
TOLUENE	11	10	2	3	3	5	20	70	92
TRICHLOROETHYLENE	11	1	0	3	*	3	3	*	3
VINYL CHLORIDE	11	0	0	.	*	.	.	*	.
ALDRIN	21	0	0	.	*	.	.	*	.
DIELDRIN	21	0	0	.	*	.	.	*	.
CHLORDANE	21	0	0	.	*	.	.	*	.
4,4-DDT	21	0	0	.	*	.	.	*	.
4,4-DDE	21	0	0	.	*	.	.	*	.
4,4-DDD	21	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	21	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	21	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	21	0	0	.	*	.	.	*	.
ENDRIN	21	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	21	0	0	.	*	.	.	*	.
HEPTACHLOR	21	0	0	.	*	.	.	*	.
HEPTACHLOR EPOXIDE	21	0	0	.	*	.	.	*	.
BHC-ALPHA	21	0	0	.	*	.	.	*	.
BHC-BETA	21	0	0	.	*	.	.	*	.
BHC (LINDANE)-GAMMA	21	0	0	.	*	.	.	*	.
BHC-DELTA	21	0	0	.	*	.	.	*	.
PCB-1242 (AROCHLOR 1242)	21	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	21	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	21	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	21	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	21	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	21	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	21	0	0	.	*	.	.	*	.

Table VI-12 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
PLANT BLANKS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	21	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	21	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	21	0	0	.	*	.	.	*	.

Table VI-13 (3)

TUBING LEACHING ANALYSIS RESULTS

Component	Micrograms/Liter	
	Original ISCO	Tygon
Bis (2-ethylhexyl) Phthalate		
Acid Extract	915	N.D.
Base-Neutral Extract	2,070	885
Phenol		
Acid Extract	19,650	N.D.
Base-Neutral Extract	N.D.	N.D.

N.D. - Not Detected

Table VI-14

COMPOUNDS DETECTED IN TREATED WATER
AT ONE OR TWO MINES
BUT ALWAYS BELOW 10 ug/1

1. *1,2-dichloroethane
2. hexachloroethane
3. *1,1,2,2-tetrachloroethane
4. *1,4-dichlorobenzene
5. 3,3'-dichlorobenzidine
6. *fluoranthene
7. bis(2-chloroethoxy) methane
8. *2,4-dinitrophenol
9. *4,6-dinitro-o-cresol
10. pentachlorophenol
11. di-n-octyl phthalate
12. benzo(a)anthracene
13. chrysene
14. *anthracene
15. fluorene
16. *phenanthrene
17. *pyrene
18. *benzo(g,h,i)perylene
19. *aldrin
20. 4,4'-DDT
21. *4,4'-DDD
22. *heptachlor
23. *heptachlor epoxide

*This compound was detected in one or more field blanks and/or controls.

Table VI-15

PRIORITY ORGANICS DETECTED BUT PRESENT IN AMOUNTS TOO SMALL TO BE EFFECTIVELY REDUCED

1. 1,1,1,-trichloroethane
2. 1,1-dichloroethylene
3. 1,2-trans-dichloroethylene
4. ethylbenzene
5. trichlorofluoromethane
6. trichloroethylene
7. 1,2-dichlorobenzene
8. naphthalene
9. dibenzo (a,h) anthracene
10. indeno (1,2,3-c,d) pyrene
11. BHC-Alpha
12. BHC-Beta
13. BHC-Gamma
14. BHC-Delta

SECTION VII

TREATMENT AND CONTROL TECHNOLOGY

INTRODUCTION

Previous sections have presented the characteristics of raw and treated effluents in the coal mine industry, including the priority, conventional, and nonconventional pollutants present in these wastewaters. The purposes of this section are to present the existing treatment practices of the coal mining industry (which should reflect, at a minimum, BPT or equivalent technology) and to present the candidate BAT treatment and control technologies and the associated levels of conventional, nonconventional and toxic pollutant reduction. These control practices will be evaluated only from a technical standpoint; cost considerations will be presented in Section VIII.

APPROACH

A summary of in-use treatment technology (BPT or its equivalent) is presented in this section for each subcategory. Next, the candidate treatment technologies applicable to BPT-treated effluents in each subcategory are reviewed. To determine the best available technology, all potentially available treatment techniques were assessed according to a number of initial criteria. These initial screening criteria are:

1. The candidate technology must produce or be capable of producing an effluent of better quality than that required under BPT guidelines.

2. The candidate technology must be in use or available to the coal mining industry or transferable from other industrial or municipal wastewater treatment applications.

3. Preliminary cost studies or cost data must be available; this information should indicate baseline cost feasibility of the candidate technology.

Applying these initial criteria, the following candidate technologies were selected:

1. Flocculant Addition,
2. Granular Media Filtration,
3. Carbon Adsorption,
4. Ion Exchange,
5. Reverse Osmosis,
6. Electrodialysis,
7. Ozonation, and
8. Sulfide Precipitation.

Next, the technical feasibility of these technologies was assessed based on the following criteria:

1. Process fundamentals,
2. Control effectiveness,
3. Non-water quality impacts,
4. Reliability,
5. Secondary waste streams, and
6. Preliminary cost/economic considerations.

The process fundamentals description is a short summary highlighting the major operating parameters, equipment required, and the mechanism for pollutant reduction or removal. The degree of this reduction is presented as the control effectiveness for each technology, in tabular form where sufficient data exist.

Third, the non-water quality impacts resulting from applications of a treatment technique are discussed. These include sludge generation, air pollution, and energy requirements. The fourth factor considered--reliability--is principally a function of the maturity of the technology; i.e., the process has been commercialized and initial problems resolved. Fifth, the generation of secondary waste streams, such as brines, are important parameters in determining the merit of each technology. Finally, preliminary cost estimates were prepared to analyze the cost effectiveness of each candidate technology.

After reviewing the above aspects of each technology and, in particular, the preliminary cost and control effectiveness, appropriate candidate treatment technologies in each subcategory were selected.

The final screening step for the BATEA determination is application of cost and economic criteria. Cost estimates are first prepared for each technology not previously eliminated (these cost curves and supporting material are presented in Section VIII). The cost curves for each treatment system are then used as input to a computer economic model. This computer model will predict the nationwide economic impact by geographic region including total cost to the industry; changes in selling price of the commodity, productivity, employment, and number of operating facilities; and import/ export fluctuations. The results of this economic assessment are contained in a separate document entitled, "Economic Impact Analysis of Proposed Effluent Limitations Guidelines, New Source Performance Standards, and Pretreatment Standards for the Coal Mining Point Source Category."

ACID MINE DRAINAGE

Current Treatment Technology

Raw wastewaters from mines exhibiting acid drainage are characterized by low pH, high dissolved iron and other metals levels. For surface operations, raw wastewaters may carry substantial sediment loads. The effluent limitations currently in force can be achieved by application of the best practicable technology to these wastewaters. For this subcategory, this level of technology includes chemical precipitation/pH adjustment, aeration, and settling. A flow chart for a typical BPT treatment system is illustrated in Figure VII-1. Each of the principal process units is discussed below.

The raw water holding pond, although not always installed, is employed by many facilities as an equalization basin. Variation in flow and pollutants, particularly pH, can be minimized by this pond. Overflow from this facility is then commonly routed to a mixing tank where pH adjustment is initiated.

pH Adjustment/Chemical Precipitation

This technology consists of the addition of an alkaline reagent to acid mine drainage to raise the pH to between six and nine. This pH change also causes the solubilities of positively charged metal ions to decrease and thus precipitate (settle as an insoluble compound) out of solution. These metal ions are replaced in solution by more acceptable calcium, magnesium and sodium ions. In general, three types of reactions occur as a result of pH adjustment:

1. Neutralization, an ion exchange reaction that, in the case of acid mine drainage, combines basic hydroxyl ions with acidic hydronium ions;

2. Oxidation, which converts ferrous iron (iron in the +2 valence state) to ferric iron (iron in the +3 valence state); and

3. Precipitation, which results from solubility decreases of toxic and other metal ions.

The precipitates are, in most cases, metal hydroxides such as ferric hydroxide ($Fe(OH)_3$) which can be removed to a great extent by settling. One of four reagents are commonly used to effect the above reactions: hydrated lime ($Ca(OH)_2$), calcined or quick lime (CaO), caustic soda ($NaOH$), or soda ash (Na_2CO_3). Selection of one of these alkaline compounds depends upon the acidity and ferrous/ferric iron ratio of the raw mine water, and the availability and cost of the reagents.

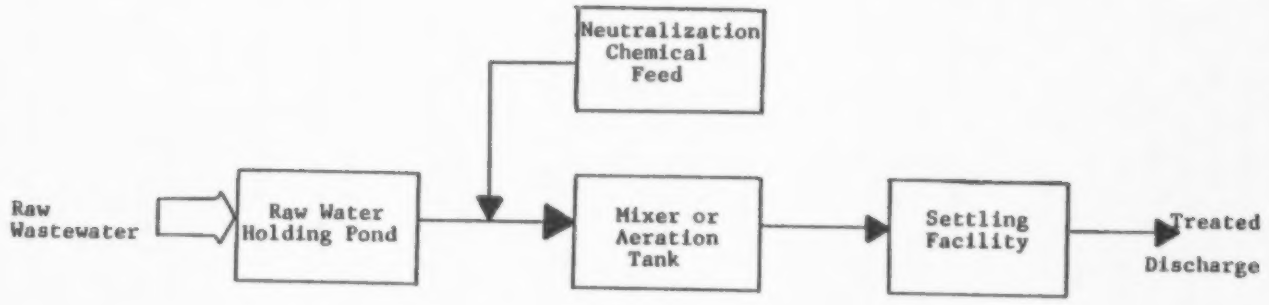

Raw Wastewater
Raw Water Holding Pond
Neutralization Chemical Feed
Mixer or Aeration Tank
Settling Facility
Treated Discharge

Figure VII-1
TYPICAL BPT TREATMENT CONFIGURATION FOR ACID MINE DRAINAGE

Hydrated Lime. This is the most commonly used reagent for pH adjustment. It can be introduced as an aqueous slurry or as a dry powder. The slurry can be prepared using the acid drainage, good quality water or treated effluent. Dry lime or lime slurry is then, in most cases, added to the acid mine drainage (AMD) in a mixing tank. Addition rates can be controlled automatically or manually.

Calcined Lime (also termed "unslaked" or "quick" lime). This can also be used as a reagent. A potential problem with the use of either calcined lime or hydrated lime is the formation of gypsum ($CaSO_4 \cdot 2H_2O$). This compound forms when calcium ions from the lime reagent combine with the typically high concentrations of sulfate ions present in AMD. Gypsum will deposit on tanks, impellers, piping, control equipment including pH probes, and other surfaces that contact the treated AMD. High concentrations of gypsum, if allowed to accumulate, may result in plugged lines and damaged equipment. This problem can be lessened with proper chemical dosages, and correctly sized pipes and tanks. The selection of the type of lime used is a matter of economics which usually favor hydrated lime except in very large installations, where use of unslaked lime becomes advantageous.

Caustic Soda or Sodium Hydroxide (NaOH). This is used as the neutralization reagent in a number of acid mines; most of these have drainage with lesser acidity and iron concentrations, or low flows. Caustic soda is a strong base, but it is also the most expensive per unit of alkaline equivalence. As an aqueous solution, it mixes readily with AMD, and reacts rapidly.

The use of an aqueous solution of caustic soda may eliminate the need for expensive dispensing and mixing equipment. Savings in capital and operating costs of such a system may more than offset the additional expense of the reagent when only small amounts of alkali are needed. Where calcium is the limiting reactant, caustic soda does not precipitate calcium sulfate. This substantially decreases gypsum deposits.

Caustic soda use also has several disadvantages. The reagent is dangerous to handle, requiring the use of protective clothing. Although it is available in 50 percent solution, this solution freezes at 54°F and thus often requires heating to remove it from the transport containers. Thus, a 20 percent solution is favored where winter temperatures are below freezing. Nevertheless, even the 20 percent solution can continue to be difficult to pump at winter temperatures. Also, because hydroxide is such a strong base, closer flow-proportioned control is required to prevent overtreatment (1).

Soda Ash or Sodium Carbonate (Na_2CO_3). This is used as an alkaline reagent by a small percentage of mining operations. Although some degree of caution must be exercised in the use of soda ash, the hazards associated with handling this material are less than with caustic soda. Similar to lime, soda ash can be added dry (ground or in briquettes), or as a slurry. The sludge formed with soda ash settles to greater densities than sludge resulting from lime addition or caustic soda, but reagent consumption is also relatively high.

Limestone. This has the lowest cost of any of the neutralizing reagents. It is used minimally, however, because of several factors. Two predominant disadvantages are that limestone has very low reactivity at high pH and its use results in the formation of gypsum. This substance coats the unreacted limestone and further reduces its reactivity. The achievable pH ceiling for limestone treatment is approximately 7.5 which is insufficient to precipitate many metals (particularly manganese) (1).

The control effectiveness of neutralization and settling on metals is dependent upon the reagent used, influent and effluent pH, temperature, flow, and the presence of any side reactions including metal chelation and mixed-metal hydroxide complexing. Complete mixing of the alkaline agent and AMD is also important to control effluent pH and metals removal. Table VII-1 presents metals removal data for lime neutralization generated in a pilot plant treatment study at EPA's Crown Field site (2).

Referring again to Figure VII-1, oxidation of iron from its ferrous to ferric state can be achieved using aeration.

Aeration

Often, aeration is accomplished by allowing the water to simply flow or cascade down a staircaselike trough or sluiceway. This causes turbulence that increases the oxygen transfer rate and therefore the oxidation reaction rate. In other cases, the air or oxygen may be supplied by one or more of the following types of aerators:

1. Diffused air systems,

2. Submerged turbine aerators, or

3. Surface aerators.

The oxidation system consists of a tank or pond fitted with one of the above aeration systems. The presence of dissolved oxygen supplied by the aerating technique oxidizes ferrous ions enhancing the formation of essentially insoluble ferric hydroxide. The resulting sludge is more easily settled. Temperature, pH, flow,

Table VII-1

TRACE ELEMENT REMOVAL BY LIME NEUTRALIZATION
- CROWN MINE PILOT PLANT STUDY -

Parameters	Spiked Influent	pH-7 mg/l	pH-9 mg/l	pH-11 mg/l
Arsenic	1.90 mg/l	.10	.04	.03
Boron	2.36	2.25	-	1.90
Cadmium	.90	.18	.08	.01
Chromium	.54	.04	.07	.05
Copper	5.30	.30	.11	.06
Mercury	.50	.02	.01	.02
Nickel	.66	.34	.08	.06
Phosphorous	9.83	3.81	2.30	3.56
Selenium	.94	.05	.16	.39
Zinc	5.65	1.01	.11	.11

Source: (2)

dissolved oxygen content, and initial concentration are all important design parameters (3).

The control performance of aeration will cause a nearly complete conversion of influent ferrous ion to the oxidized or ferric state. Further, many volatile organics present are often stripped or oxidized by this process to nondetectable levels (4).

Referring again to Figure VII-1, the neutralized wastewater, laden with insoluble precipitates, is routed to a settling facility prior to final discharge.

Settling

The process of sedimentation removes the suspended solids, which includes the insoluble precipitates. Sedimentation can be accomplished in a settling pond or clarifier (a settling tank). The settling pond can be created by excavating a depression. The extent of solids removal depends upon surface area, retention time, flow patterns, settling characteristics of influent suspended solids, and other operating parameters of a particular installation. Clarifiers are mechanical settling devices which can be used where insufficient land exists for construction of a pond. Clarifiers operate on essentially the same principles as a sedimentation pond. The most significant advantage of a clarifier is that closer control of operating parameters such as retention time and sludge removal can be maintained, while problems such as runoff from precipitation and short-circuiting can be avoided. Center feed (the most common), rectangular, and peripheral feed basins are a few of the several clarifier designs.

Center feed clarifiers have four distinct sections: the inlet zone, the quiescent settling zone, the outlet zone, and the sludge zone. The inlet zone allows a smooth transition from the high velocities of the inlet pipe to the low uniform velocity needed in the settling zone. Careful control of the velocity change is necessary to avoid turbulence, short-circuiting, and carryover. The quiescent settling zone must be large enough to reduce the net upward water velocity to below the settling rate of the solids. The outlet zone provides a transition from the low-velocity settling zone to the relatively high overflow velocities. The sludge zone must effectively settle, compact, and collect the solids and remove this sludge without disturbing the settling zone above. The bottom of the circular clarifier is usually sloped five to eight degrees to the center of the unit where sludge is collected in a hopper for removal. Mechanically driven sludge rakes rotate continuously and scrape the sludge down the sloped bottom to the sludge hopper (see Figure VII-2).

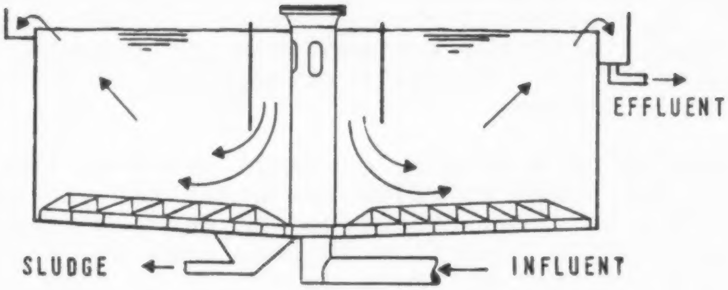

EFFLUENT
SLUDGE
INFLUENT

Figure VII-2

CIRCULAR CENTER FEED CLARIFIER WITH
A SCRAPER SLUDGE REMOVAL SYSTEM

Source: (5)

The rectangular basin or clarifier is similar to a section of a center feed clarifier with the inlet at one end and the outlet at the other. Usually a flight system removes sludge in the rectangular basin. The flights travel along the basin bottom to convey the sludge to a discharge hopper. To avoid turbulence, which would hinder settling, the flight system moves slowly. This type of clarifier has the advantage that common walls can be used between multiple units to reduce construction costs (see Figure VII-3).

The peripheral feed or rim feed clarifiers shown in Figure VII-4, are designed to utilize the entire volume of the circular clarifier basin for sedimentation. In both types of clarifiers, water enters the lower section at the periphery at very low velocities to provide immediate settling of large particles. In a peripheral take-off configuration, the flow then accelerates toward the center and subsequently drops as the flow reverses and redirects to a peripheral overflow weir. In the center take-off system, effluent is discharged through weirs located centrally. Peripheral feed clarifiers are sensitive to temperature changes and load fluctuations. Sludge recirculation is difficult with these types of clarifiers.

Clarification of acid mine drainage produces two secondary streams: the clear overflow or decant and the sludge underflow. The overflow is often discharged in current treatment systems. The dilute solids underflow stream, usually of only 5 to 10 percent solids content is often dewatered further before final disposal. Evaporation, centrifugation, and vacuum filtration are several techniques that may be used to further dewater sludges from clarifiers prior to ultimate disposal.

Installation of clarifiers to provide sedimentation is principally in hilly or mountainous areas where suitable land for a sedimentation pond is difficult to obtain.

Ponds can also be installed to provide sedimentation capability. The settling pond can be created by excavating a depression or damming a natural runoff water course. This also includes use of an abandoned strip mine pit at surface facilities. The purpose of a sediment basin is to remove sediment from runoff and thus protect drainageways, properties, and rights-of-way below the sediment basin from sedimentation (6).

Construction of these basins is regulated primarily by the Office of Surface Mining Reclamation and Enforcement (OSM) in the Department of Interior. A settling pond operates on the principle that as the sediment laden water passes through the pond, the particles will settle to the bottom and be trapped. Some of the factors affecting the settling velocity of a particle include water viscosity (which is a sensitive function of temperature),

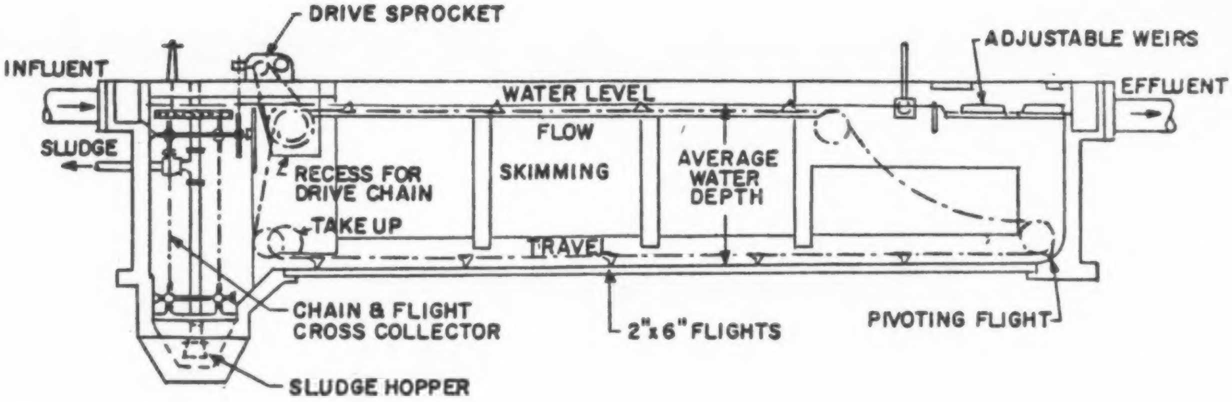
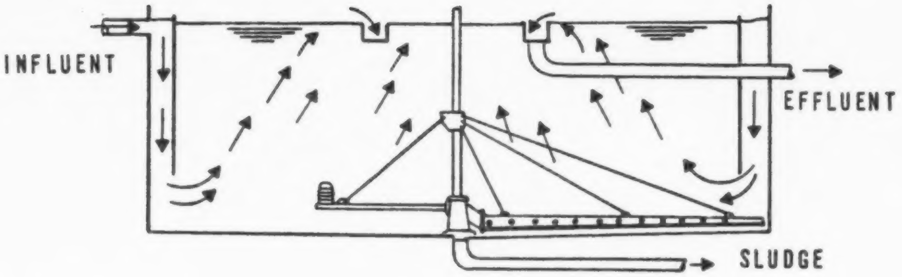

DRIVE SPROCKET
ADJUSTABLE WEIRS
INFLUENT
EFFLUENT
WATER LEVEL
SLUDGE
FLOW
SKIMMING
RECESS FOR DRIVE CHAIN
AVERAGE WATER DEPTH
TAKE UP
TRAVEL
CHAIN & FLIGHT CROSS COLLECTOR
2"x6" FLIGHTS
PIVOTING FLIGHT
SLUDGE HOPPER

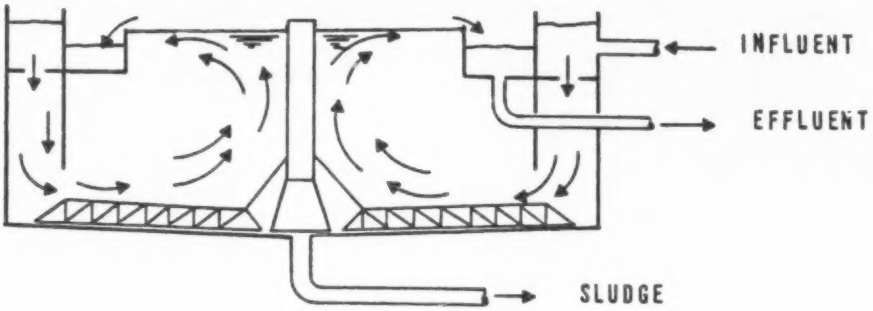
Figure VII-3

RECTANGULAR SEDIMENTATION CLARIFIER
WITH CHAIN AND FLIGHT COLLECTOR

Source: (5)


INFLUENT
EFFLUENT
SLUDGE

(a) CIRCULAR RIM-FEED, CENTER TAKE-OFF CLARIFIER WITH A HYDRAULIC SUCTION SLUDGE REMOVAL SYSTEM


INFLUENT
EFFLUENT
SLUDGE

(b) CIRCULAR RIM-FEED, RIM TAKE-OFF CLARIFIER

Figure VII-4

PERIPHERAL FEED CLARIFIERS

Source: (5)

and the density, size, and shape of the particle. For instance, as the temperature increases, the water viscosity decreases, and thus a particle will have a greater settling velocity in warm water (7, 8, 9, 10, 11, 12).

As indicated previously, the use of sedimentation facilities is required by OSM regulations and has been commonplace in the industry for some time. Some mines, particularly in mountainous areas, may opt for several small ponds. These ponds are usually constructed in series, with the decant of one flowing into another. Other acid mine drainage treatment plants use two ponds in a parallel configuration. When the solids level in one pond has reached capacity, flow is diverted to the second pond and the sludge in the first is either removed by dredging or allowed to undergo drying and compaction which greatly reduces the sludge volume. When the second pond is full, flow is returned to the first and the cycle is repeated.

Application of the above treatment technologies to acid mine drainage will result in achievement of the BPT limitations discussed in Reference 13.

Candidate Treatment Technologies

Source control options are discussed under the best management practices subsection (Section X). The candidate technologies examined for treatment of acid mine drainage were previously listed and include:

1. Flocculant Addition,
2. Granular Media Filtration,
3. Activated Carbon,
4. Ion Exchange,
5. Reverse Osmosis,
6. Electrodialysis,
7. Ozonation, and
8. Sulfide precipitation.

The first two technologies were selected for further study. The remaining technologies and the reasons for their rejection are discussed below.

Carbon Adsorption

Activated carbon technology is predicated upon the considerable sorptive properties of granular or powdered carbon. The activated carbon process is often associated with organics removal, although some reduction of heavy metals can also be accomplished (14, 15).

A typical system is depicted in Figure VII-5. Contaminated water is introduced across a fixed or moving bed of granular or powdered activated carbon. Residence time in the bed is the major control parameter for pollutant removal. When a bed becomes fully loaded or exhausted, the adsorbent must be regenerated or disposed of. Regeneration (for granulated carbon only) is usually effected by heating to volatilize any organics and/or heavy metals.

The adsorptive capacity of carbon depends on the pore size, typical size of the sorbed molecules, pH of the solution, temperature, and the initial pollutant concentration. Adsorption capacity generally increases as pH decreases and, normally, adsorption efficiency increases as the concentration increases (14). A large amount of data is available on organic pollutant removal by this technology, whereas less data exist in the literature for metals removal. For cases where metals are present in the untreated wastewater at the parts per million level, significant reductions of Sb, As, hexavalent Cr, Sn, Ag, Hg, Pb, and Ni are documented in the literature (16). Cu, Cd, and Zn removals vary widely, while concentrations of Ba, Se, Mo, Mn, and W are not significantly reduced. BPT-treated effluents in the coal mining industry contain toxic metals at the parts per billion level, and data quantifying reductions beyond these levels are not available.

Table VII-2 presents an estimate of general effluent water quality parameters. Suspended solids will quickly foul an activated carbon column, hence, filtration, which will itself reduce metals concentrations, is a required pretreatment step in an activated carbon system. Activated carbon columns would also be very difficult to operate at remote sites. Some provision for regeneration (typically including multiple hearth furnaces) is required to make such a system cost effective. Beyond this, the substantial capital cost for equipment and the high operating costs for carbon purchase and regeneration cannot be justified for any potential additional reductions of metals beyond BPT. Based on these factors, activated carbon is not selected as a BAT option for further analysis.

Ion Exchange

The property of reversible interchange of ions between solids and liquids is the fundamental principle of ion exchange. Ion-rich water is introduced into an exchanger or column in which a solid resin bed resides. This resin, most commonly a type of styrene-divinylbenzene copolymer, has the ability to sorb (capture) and contain ions before release during regeneration. Of the many ion exchange configurations available, a typical arrangement, shown in Figure VII-6, is a cation column using an acidic solution for

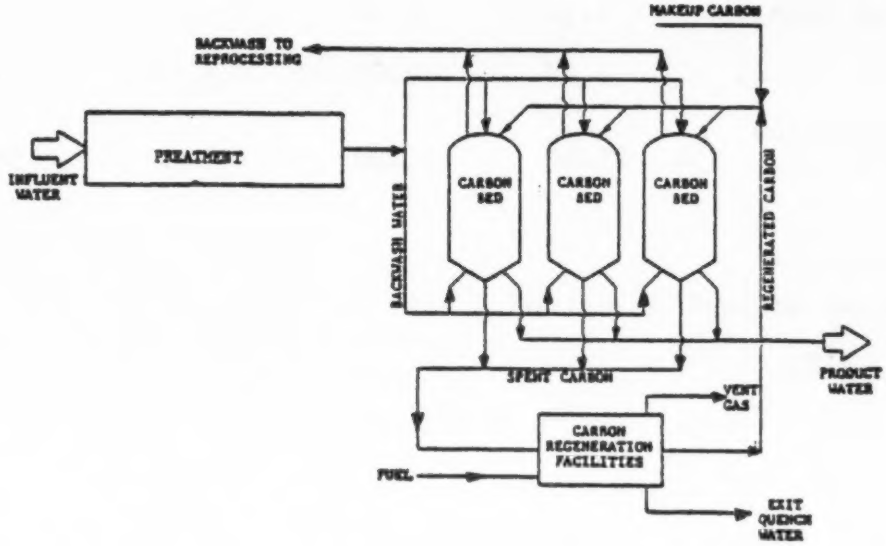

MAKEUP CARBON
BACKWASH TO REPROCESSING
PRETREATMENT
INFLUENT WATER
BACKWASH WATER
CARBON BED
CARBON BED
CARBON BED
REGENERATED CARBON
PRODUCT WATER
SPENT CARBON
VENT GAS
CARBON REGENERATION FACILITIES
FUEL
EXIT QUENCH WATER

Figure VII-5
ACTIVATED CARBON SYSTEM

Table VII-2

ESTIMATED EFFLUENT CONTAMINANT LEVELS - ACTIVATED CARBON

	Acid Mines		Alkaline Mines	
	30-Day Average*	Daily Maximum*	30-Day Average*	Daily Maximum*
pH	6-9.00	6-9.00	6-9.00	6-9.00
Total iron	2.00	3.00	2.00	3.00
Dissolved iron	0.30	0.60	--	--
Manganses, total	2.00	4.00	--	--
Total suspended solids	15.00	30.00	15.00	30.00

---

*All values in mg/l except pH.

Source: (15)

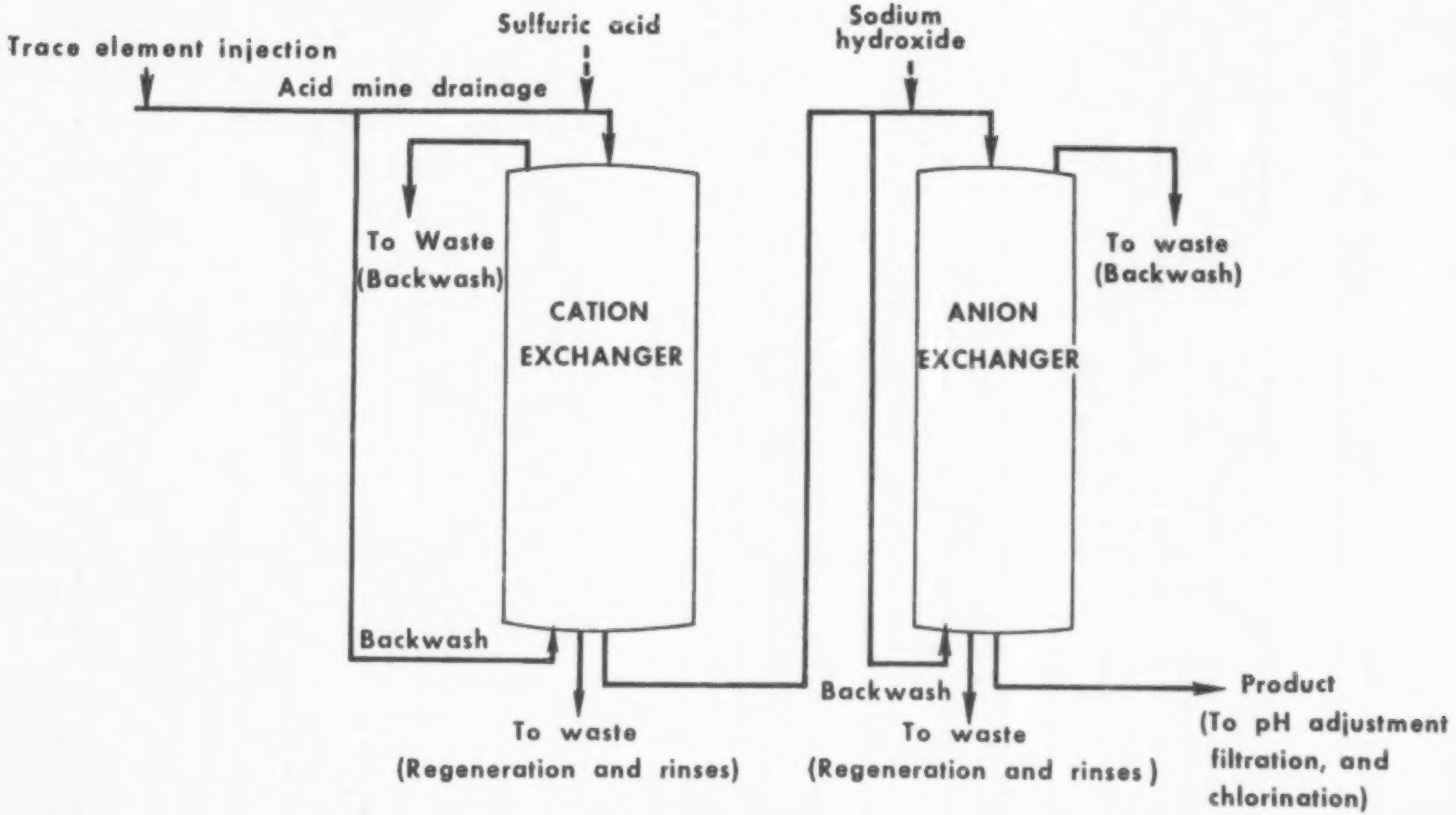

Trace element injection
Acid mine drainage
Sulfuric acid
Sodium hydroxide
To Waste (Backwash)
CATION EXCHANGER
Backwash
To waste (Regeneration and rinses)
ANION EXCHANGER
To waste (Backwash)
Backwash
To waste (Regeneration and rinses)
Product (To pH adjustment filtration, and chlorination)

Figure VII-6

CONCEPTUAL DESIGN OF AN ION EXCHANGE SYSTEM

Source: (2)

regeneration, followed by an anion column using an alkaline regeneration solution to elute (deadsorb with a solvent) sorbed anions.

Individual ion exchange systems do not generally exhibit equal affinity or capacity for each ionic species, and hence may not be suited for broad-spectrum removal schemes in wastewater treatment. Their behavior and performance are usually dependent upon pH, temperature, and concentration. The highest removal efficiencies are generally observed for polyvalent ions. In wastewater treatment, some pretreatment or preconditioning of wastes to adjust suspended solid concentrations and other parameters is likely to be necessary.

High concentrations of ions other than those to be recovered may interfere with practical removal. Calcium ions, for example, are generally collected along with the divalent heavy metal cations of copper, zinc, lead, etc. High calcium ion concentrations, therefore, may make ion exchange removal of divalent heavy metal ions impractical by causing rapid loading of resins.

Ion exchange can effectively produce low levels of metals. However, although ion exchange is a commercially available technology, it becomes uneconomical on streams high in dissolved solids due to resin replacement costs. Even at less than 500 ppm dissolved solids, ion exchange is expensive and requires relatively sophisticated equipment and control (2, 3, 17). Table VII-3 presents data from an EPA mine drainage study showing metals removal (2).

A number of operational disadvantages are associated with this technology. A secondary pollution stream is generated and must be treated. Iron fouling is a common problem in the cation sorption column, necessitating an acidification step prior to the first resin bed. Also, a final effluent neutralization step is required if the pH remains too high downstream of the anion exchanger. Acidic and basic regenerant solutions are required. Operation of this relatively sophisticated system at remote sites, especially in the mountainous terrain of Appalachia, would be very difficult. Costs per thousand gallons of treated water are also substantially higher than the selected technologies while not demonstrating better removal capacity.

For these reasons, this technology is not selected as a BAT option for further analysis.

Reverse Osmosis

Reverse osmosis is the process of concentrating ions on one side of a semipermeable membrane by the application of external pressure. This pressure must be sufficient to overcome the osmotic

Table VII-3

ION EXCHANGE EFFLUENT WATER QUALITY (in mg/l)

Parameter	Spiked Feed (mean)	Cation Effluent (mean)	Anion Effluent (mean)
pH	4.8	1.9	9.9
Arsenic	2.47	1.68	0.52
Cadmium	0.95	0.04	0.001
Chromium	0.63	0.05	0.01
Copper	7.27	0.11	0.03
Iron, total	160	2.1	0.05
Manganese	3.9	0.09	0.05
Mercury	0.72	0.07	0.001
Nickel	0.86	0.02	0.02
Selenium	1.34	1.19	0.09
Zinc	7.44	0.14	0.03

Source: Adapted from (2)

gradient which acts in the opposite direction--hence, the name reverse osmosis. This is schematically illustrated in Figure VII-7. Water is separated from the ions by forcing it across a membrane, which is impervious to ion transfer. Treated water is then decanted and discharged, while the brine requires further treatment prior to disposal.

Since 1966, the EPA has been sponsoring and conducting research to determine the potential of using reverse osmosis to treat acid mine drainage. This EPA work includes pilot plant studies that have been undertaken at the Crown Mine Drainage Control Field Site (2). Results from these and other research efforts (19) have shown that in treating mine drainage, reverse osmosis can remove nearly all dissolved solids and up to 95 percent of the aluminum, iron, calcium, magnesium, manganese, sodium, and sulfate ions.

The basic reverse osmosis system consists of a number of potential pretreatment steps (e.g., filtration, pH adjustment); a high pressure pump (400 to 800 psig); a reverse osmosis membrane package; and post-treatment, if necessary (Figure VII-8).

One of the problems encountered in applying reverse osmosis to acid mine drainage treatment is fouling of the membranes. Fouling of a semipermeable membrane is defined as any reduction in permeability or efficiency due to blinding of the membrane by suspended solids, age of the membrane, or deterioration of the membrane. Membrane fouling progressively lowers water recovery until recover rates are no longer practical. The two major causes of fouling in the treatment of acid mine drainage are chemical and bacterial. Two solutions for the bacterial fouling are to disinfect the water before it enters the reverse osmosis unit or to adjust the mine water to below pH 2.5 which greatly retards bacterial growth. The two chief chemical compounds that can foul the membrane are the sulfates of iron and calcium. Under normal conditions ferric iron fouling can be controlled either by the addition of an acid to maintain a pH below 3.0 or by the addition of reducing chemicals such as sodium sulfite, to reduce ferric iron to ferrous. The stream can also be filtered prior to polishing in a reverse osmosis unit to remove suspended material such as ferric or calcium sulfate. Table VII-4 presents effluent pollutant reductions of acid mine drainage achievable by reverse osmosis.

Although reverse osmosis is slightly more effective than lime neutralization and settling for metals removals, this technology is very expensive and appropriate only for low volume, high dissolved solids feed streams. Sophisticated equipment and control required, and the power and maintenance costs of the pressure pump and process membrane. Further, concentrated brine requiring further treatment is generated from the separation chambers.

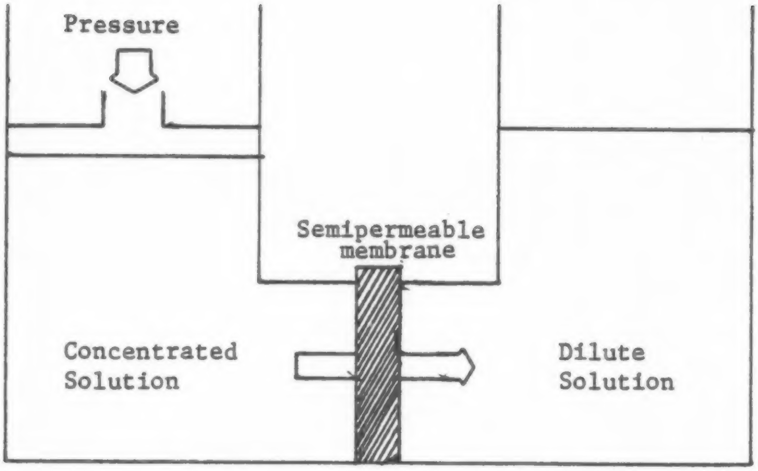

Pressure
Semipermeable membrane
Concentrated Solution
Dilute Solution

Figure VII-7

TRANSFER AGAINST OSMOTIC GRADIENT IN REVERSE OSMOSIS SYSTEM

Source: Adapted from (18)

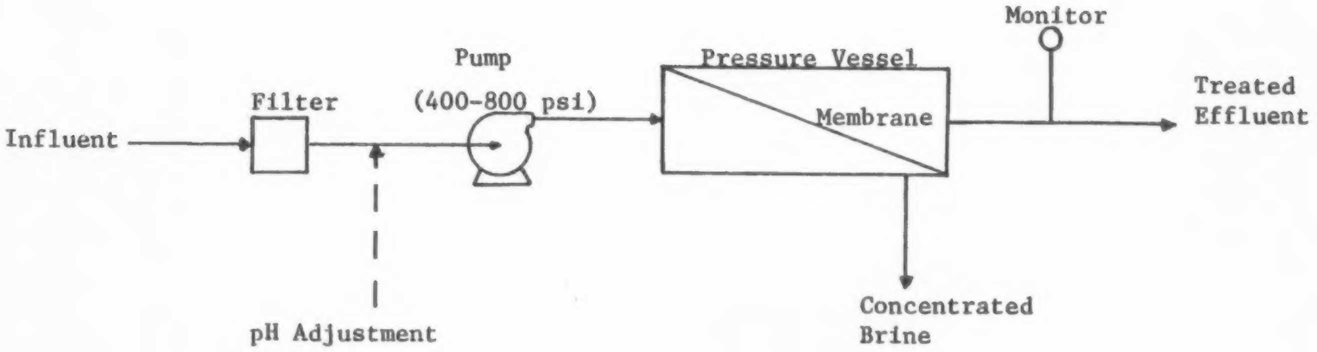

Influent
Filter
Pump
(400-800 psi)
pH Adjustment
Pressure Vessel
Membrane
Concentrated
Brine
Monitor
Treated
Effluent

Figure VII-8

SCHEMATIC OF REVERSE OSMOSIS SYSTEM

Source: Adapted from (18)

Table VII-4

EFFLUENT WATER QUALITY ACHIEVED BY REVERSE OSMOSIS
(in mg/l)

Parameter	Spiked Feed (mean)	Product (mean)	Brine (mean)
pH	2.2	2.0	3.6
Arsenic	2.29	0.01	3.58
Cadmium	0.83	0.006	1.22
Chromium	0.54	0.01	0.82
Copper	6.18	0.01	9.12
Iron, total	170	0.30	270
Manganese	110	0.20	180
Mercury	0.28	0.06	0.17
Nickel	0.74	0.01	1.10
Selenium	1.17	0.11	1.83
Zinc	6.25	0.06	9.63

Source: Adapted from (2)

Based on the above considerations, reverse osmosis is not selected as a BAT-level treatment technology.

Electrodialysis

Electrodialysis can be used for the control of dissolved inorganics in coal mine wastewaters. The technology is based upon differentially permeable membranes operating in an electric field.

Contaminated water is introduced into a cell or "stack" of alternating anion- and cation-permeable membranes. With an electric field applied across the stack providing the driving force, ions are forced into alternating cells, while deionized water is withdrawn from the remaining cells (Figure VII-9).

A small bench-scale electrodialysis unit was tested by the Federal Water Pollution Control Administration at its Mine Drainage Treatment Laboratory, Norton, West Virginia, in cooperation with the Office of Saline Water (17). When used on drainage without pretreatment, the cathode cell quickly became fouled with iron. In those cases where the mine drainage was pretreated by lime neutralization for iron removal, the unit operated satisfactorily.

Electrodialysis is a costly technology suitable chiefly for low flow, high dissolved solids streams, with pretreatment frequently necessary. Energy requirements to maintain the electrical field add significantly to the operating costs. The process also produces a secondary stream of concentrated brine that requires further treatment.

Based on the above considerations, electrodialysis is not selected as a BAT-level treatment technology.

Ozonation

Ozone is an unstable molecule, O_3, that is a powerful oxidant. Its primary application to the coal mining industry is oxidation of metal compounds that render them less soluble and thus increases the settling rates. It has also been shown to be effective in the oxidation of soluble manganese to an insoluble state which can be removed prior to discharge into streams.

Because of the instability of ozone, facilities for on-site generation are required. The gas is generated by passing air across a high voltage field (5 to 30 kilovolts). The gas is then injected into a stream where oxidation occurs (3).

Preliminary cost estimates show ozonation to be a relatively costly technology. Further, no data are available to quantify toxic metals removal by ozonation systems on coal mine drainage.

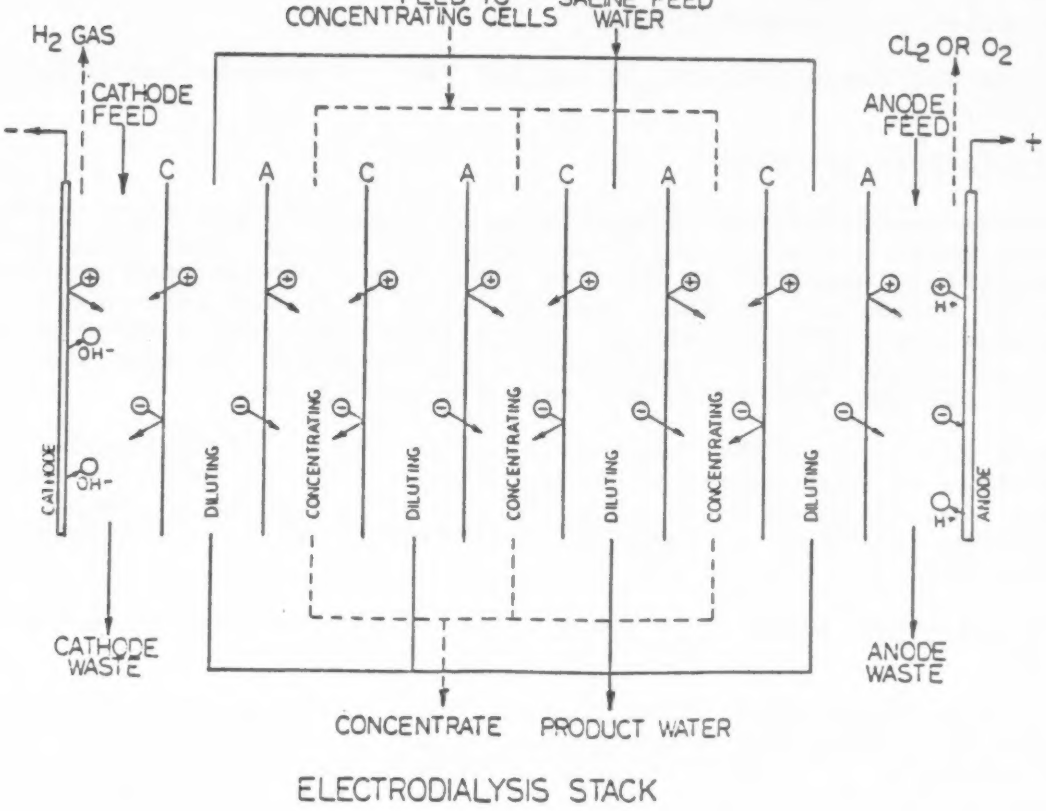

FEED TO CONCENTRATING CELLS
SALINE FEED WATER
H_2 GAS
CATHODE FEED
CL_2 OR O_2
ANODE FEED
C
A
C
A
C
A
C
A
+
OH-
OH-
H+
H+
CATHODE
DILUTING
CONCENTRATING
DILUTING
CONCENTRATING
DILUTING
CONCENTRATING
DILUTING
ANODE
CATHODE WASTE
ANODE WASTE
CONCENTRATE
PRODUCT WATER
ELECTRODIALYSIS STACK

Figure VII-9

CONFIGURATION OF ELECTRODIALYSIS CELLS

Source: (17)

Finally, suspended solids in substantial concentrations impede ozonation performance (16).

Because of these factors, ozonation was not selected as a BAT option.

Sulfide Precipitation

Sulfide precipitation is analogous to lime precipitation in that heavy metal cations (positively charged) are combined with anions (negatively charged) to form an insoluble compound that settles out of solution. In this process, sulfide is the anion used. Sulfide precipitates vary in solubility which will determine the removal efficiency. Heavy metal sulfides are in general very insoluble and have excellent settling properties.

Table VII-5 gives the theoretical solubilities of hydroxides and sulfides of various metals in pure water. In addition to having lower solubilities than hydroxides in the alkaline pH ranges, sulfides also tend to have low solubilities in the pH 7 range or below (14).

Several steps enter into the process of sulfide precipitation (16):

1. Preparation of sodium sulfide. Although this product is often in oversupply from byproduct sources, it can also be made by reduction of sodium sulfate. The process involves an energy loss in the partial oxidation of carbon (such as that contained in coal) as follows:

$$Na_2SO_4 + 4C \longrightarrow Na_2S + 4CO \text{ (gas)}$$

2. Precipitation of the pollutant metal (M) in the waste stream by an excess of sodium sulfide:

$$Na_2S + MSO_4 \longrightarrow MS \text{ (precipitate)} + Na_2SO_4$$

3. Physical separation of the metal sulfide in thickeners or clarifiers, with reducing conditions maintained by excess sulfide ion.

4. Oxidation of excess sulfide by aeration:

$$Na_2S + 2O_2 \longrightarrow Na_2SO_4$$

In practice, sulfide precipitation can be best applied when the pH is sufficiently high (greater than eight) to assure generation of sulfide, rather than bisulfide ion or hydrogen sulfide gas. A process utilizing ferrous sulfide as the principal source of sulfide ion has been developed and appears to overcome the problem

Table VII-5

THEORETICAL SOLUBILITIES OF HYDROXIDES AND SULFIDES OF HEAVY METALS IN PURE WATER

Metal	Solubility of Metal Ion (mg/l)	
	As Hydroxide	As Sulfide
Cadmium (Cd^{++})	2.3×10^{-5}	6.7×10^{-10}
Chromium (Cr^{+++})	8.4×10^{-4}	No precipitate
Cobalt (Co^{++})	2.2×10^{-1}	1.0×10^{-8}
Copper (Cu^{++})	2.2×10^{-2}	5.8×10^{-18}
Iron (Fe^{++})	8.9×10^{-1}	3.4×10^{-5}
Lead (Pb^{++})	2.1	3.8×10^{-9}
Manganese (Mn^{++})	1.2	2.1×10^{-3}
Mercury (Hg^{++})	3.9×10^{-4}	9.0×10^{-20}
Nickel (Ni^{++})	6.9×10^{-3}	6.9×10^{-8}
Silver (Ag^{+})	13.3	7.4×10^{-12}
Tin (Sn^{++})	1.1×10^{-4}	3.8×10^{-8}
Zinc (Zn^{++})	1.1	2.3×10^{-7}

Sources: (20, 21, 22)

of generating H_2S from excess sulfide. The sulfide is released from the FeS only when other heavy metals with lower equilibrium constants for their sulfide form are present in solution. If the pH can be maintained at 8.5 to 9, the liberated iron will form a hydroxide and precipitate out as well.

Although very effective in pollutant removal, sludge produced from sulfide precipitation is easily degraded to soluble salts that will leach toxic materials. Sludge produced from lime addition is much more stable (15).

The most probable application of sulfide technology is as a polishing unit downstream of a lime precipitation unit. However, to be implemented in the coal industry, the problem of potential leaching of soluble salts from sulfide precipitaiton sludge must be mitigated or circumvented. Also, the cost of operation with sulfides is much higher than lime neutralization, with only slight improvement in effluent quality. These factors preclude sulfide precipitation from being considered as a candidate best available technology.

The two technologies recommended for further evaluation and economic impact assessments are flocculant addition and granular media filtration. These are discussed in the following paragraphs.

Flocculant Addition

Flocculant addition is a term often used interchangeably with chemical coagulation. The process involves the aggregation and settling of suspended particles by the addition of a coagulant aid. Technically, coagulation involves the reduction of electrostatic surface charges and the initial formation of aggregated material. Coagulation is essentially instantaneous in that the only time required is that time necessary for dispersing the chemicals in solution. Flocculation is the time dependent physical process of the aggregation of wastewater solids into particles large enough to be separated by sedimentation, flotation, or filtration.

For particles in the colloidal and fine supracolloidal size ranges (less than one to two micrometers), natural stabilizing forces (electrostatic repulsion, physical repulsion by absorbed surface water layers) predominate over the natural aggregating forces (van der Waals) and the natural mechanism which tends to cause particle contact (Brownian motion). The function of chemical coagulation of wastewater may be the removal of suspended solids by destabilization of colloids to increase settling velocity, or the removal of soluble metals by chemical precipitation or adsorption on a chemical floc (16).

There are three different types of flocculants: inorganic electrolytes, natural organic polymers and synthetic organic polyelectrolytes. Inorganic electrolytes are salts or multivalent ions such as alum (aluminum sulfate) and act by neutralizing the charged double layer of colloidal particles. Natural organic polymers are derived from starch, vegetable materials, or monogalactose, and act to agglomerate colloidal particles through hydrogen bonding and electrostatic forces. Synthetic polyelectrolytes are polymers that incorporate ionic or other functional groups along the carbon chain in the molecule. The functional groups can be either anionic (attract positively charged species), neutral or cationic (attract negatively charged species). Polyelectrolytes function by electrostatic bonding and the formation of physical bridges between particles, thereby causing them to agglomerate.

The colloidal particles in AMD sludge usually carry a negative charge. Consequently a cationic flocculant must be used. Synthetic polyelectrolytes are most frequently employed since they function best in the high ionic strength solutions encountered in AMD.

Chemical coagulants are most commonly added upstream of sedimentation ponds, clarifiers, or filter units to increase the efficiency of solids separation. The settling solids are more effective in adsorbing fine metal hydroxide precipitates. As these fine particles are agglomerated and settled, equilibrium relationships will cause additional dissolved metals to react and form additional insoluble precipitates. The major disadvantage of coagulant addition to a raw wastewater stream is the production of large quantities of sludge, which must remain in storage within the sedimentation facility. Therefore, raw wastewaters are normally treated by removal of easily settled particles in a primary sedimentation pond. Coagulants are then added to this effluent prior to secondary settling or filtration. In most cases, chemical coagulation can be used with minor modifications and additions to existing treatment systems. In mines with acid drainage, this would be accomplished by polymer addition downstream of neutralization and primary settling facilities.

To assist in determination of performance characteristics of this technology at acid mines, a treatability study, included as a supplement to this report (23), was performed at four coal mine sites exhibiting acid mine drainage. Raw acid mine drainage samples (from the Crown, Norton, Hollywood, and Will Scarlet sites) were treated via lime neutralization and precipitation, flocculation, aeration and settling.

Chemical dosage rates and polymer selection were determined by jar tests. Settling tests were then conducted in an eight inch inner diameter by eight foot high settling tube to establish performance data. Spiking solutions containing priority metals were added to the acid mine drainage to raise influent concentrations to levels significant for measurement of test parameters. The chief objective of the study was to establish priority metals and suspended solids concentrations achievable by application of chemically aided precipitation.

Settling tests performed with dosages of each chemical are summarized in Table VII-6. Influent suspended solids concentrations are recorded after addition of lime. As can be seen from Table VII-6, flocculant addition consistently reduces effluent suspended solids to 20 mg/l or less. In fact, reductions below 10 mg/l are frequent. Also, in other industries, such as ore mining, reductions via flocculant addition of total suspended solids to 15 mg/l and less are typical.

The removal of priority metals was also evaluated for each of the 28 settling tests. Because spiking solutions were not readily obtainable and background levels were less than the detection limits, no data could be recorded for removals of arsenic, antimony, selenium, and thallium. Referring to Table VII-7, consistently high removals were achieved for beryllium, cadmium, chromium, copper, iron, mercury, nickel, lead, and zinc. Less consistent reduction is achieved for silver and manganese. These effluent levels are summarized in Table VII-7.

A number of points concerning this table should be made. First, raw mine drainage from these facilities does not exhibit high (>1.0 mg/l) concentrations of priority metals. Copper, lead, zinc, chromium (hexavalent), mercury, nickel, cadmium, and manganese were thus added to the raw drainage in about half of the tests to yield a concentration of 3 mg/l for each of the metals prior to neutralization and flocculant addition. Due to an inadvertent error, the spiked solutions used at the Crown site produced an initial concentration of only 0.3 mg/l for each spiking priority metal. At Norton, these compounds were added as nitrates and at Hollywood, chloride metal salts were utilized.

Second, the quantity of lime required to neutralize the acidity in the drainage from Will Scarlet was so voluminous for tests S-3 through S-6 that the settled sludge kept the lower sampling tap (where metal samples were obtained) covered throughout the test. Thus, analytical results are available on the metals contained in AMD sludge, but are of no value and, as such, are not included on Table VII-7.

Thirdly, raw water characteristics from the Crown site are presented as settling tests C-1 and C-2. This is also true of the Norton site where test N-1 summarizes raw mine water settling characteristics. These tests were run without chemical addition to establish baseline performance data. Tests on raw water at

Table VII-6

SUMMARY OF SETTLING TESTS PERFORMED

Mine	Test No.	Spiked	Chemicals Added			Initial pH	Final pH	Suspended Solids (mg/1)	
			Lime (mg/1)	Sodium Sulfide (mg/1)	Polymer (mg/1)			Influent	Effluent
Crown	C-1		0	0	0	5.0	5.0	15.95	17.8
	C-2	x	0	0	0	4.9	4.9	11.6	14.4
	C-3		350	0	4[a]	-	7.1	466	19.0
	C-4	x	350	0	4[a]	-	7.0	414	15.8
	C-5		420	0	1[a]	-	7.7	434	3.4
	C-6	x	425	0	2[a]	-	7.8	535	2.0
Norton[d]	N-1		0	0	0	2.8	2.8	3.9	3.0
	N-2		300	0	2.0[a]	2.8	9.4	448	4.4
	N-3	x	290	0	2.0[a]	2.9	6.4	230	5.8
	N-4		275	0	0.5[b]	2.8	8.2	199	6.4
	N-5		270	0	1.0[b]	2.8	8.1	222	8.6
	N-6	x	300	0	1.0[b]	2.9	8.1	217	8.2
Hollywood[d]	H-1		250	0	2.0[a]	3.5	7.2	368	7.6
	H-2	x	265	0	1.0[a]	3.6	8.8	348	9.0
	H-3		225	0	1.0[a]	3.7	8.4	388	8.0
	H-4	x	250	0	1.0[b]	3.7	7.5	292	8.5
	H-5		260	0	1.0[c]	3.6	9.5	322	4.0
	H-6	x	340	0	1.0[c]	3.8	9.6	404	4.2
	H-7		275	80	1.0[c]	3.8	9.2	412	3.8
	H-8	x	360	130	1.0[c]	3.6	9.7	520	1.3
	H-9		300	0	1.0[c]	3.7	9.6	360	1.8
	H-10	x	445	0	1.0[c]	3.7	10.1	484	2.0
Will Scarlet[d]	S-1		10,400	0	1.0[c]	2.5	9.7	23,390	20.6
	S-2	x	17,325	0	1.0[c]	2.6	10.0	63,220	9.2
	S-3		7,660	0	2.0[c]	2.5	8.2	22,950	[e]
	S-4	x	20,000	0	4.0[c]	2.4	11.0	42,400	[e]
	S-5		15,220	0	2.0[c]	2.6	9.6	24,850	[e]
	S-6	x	11,870	670	2.0[c]	2.6	9.9	29,400	[e]

Notes:

[a] Dowell 144
[b] Dowell 905N
[c] Magnifloc 1820A
[d] All tests include 30 minute aeration of sample.
[e] Sludge was sampled from tap so no meaningful value could be recorded.

Source: (23)

Table VII-7

SUMMARY OF TEST RESULTS FOR METALS REMOVAL (mg/1) BY BPT AND FLOCCULANT ADDITION

Mine	Test No.	Effluent pH	TDS	Ag	As	Be	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	Zn
Crown	C-1 (Raw)																	
	Influent	4.9	3140	DL	DL	.008	.038	.047	.019	155	DL	4.6	.26	.002	DL	DL	DL	.400
	Effluent	5.0	3360	DL	DL	.007	.033	.042	.019	161	DL	4.7	.25	.008	DL	DL	DL	.400
	C-2 (spiked)																	
	Influent	4.9	3510	.011	DL	.007	.150	.086	.111	155	.80	4.7	.31	.280	DL	DL	DL	.470
	Effluent	4.7	3440	.007	DL	.007	.141	.085	.105	142	.126	4.3	.29	.294	DL	DL	DL	.430
	C-3																	
	Influent	7.0	3520	DL	DL	.008	.040	.038	.006	154	DL	4.5	.30	DL	DL	DL	DL	.390
	Effluent	7.2	3490	.019	DL	DL	.021	.041	.008	13	DL	2.9	.12	DL	DL	DL	DL	.008
	C-4 (spiked)																	
	Influent	7.0	3500	.006	DL	.007	.130	.089	.088	122	.003	3.9	.31	.340	DL	DL	DL	.390
	Effluent	7.0	3370	.016	DL	DL	.060	.047	.009	23	.032	3.4	.18	DL	DL	DL	DL	.031
	C-5																	
	Influent	7.7	3460	.015	DL	.007	.038	.058	.016	138	DL	4.2	.28	.002	DL	DL	DL	.378
	Effluent	7.7	3410	.015	DL	DL	.020	.047	DL	1.5	DL	1.9	.13	DL	DL	DL	DL	.442
	C-6 (spiked)																	
	Influent	7.8	3610	.012	DL	.006	.142	.090	.094	138	.170	4.2	.32	.200	DL	DL	DL	.410
	Effluent	7.8	3400	.008	DL	DL	.024	.046	.010	.82	.024	1.9	.11	DL	DL	DL	DL	DL
	Detection Limits	---	---	.005	.005	.001	.001	.002	.005	.005	.001	.005	.005	.001	.005	.010	.002	.002

Table VII-7 (Continued)

SUMMARY OF TEST RESULTS FOR METALS REMOVAL (mg/1) BY BPT AND FLOCCULANT ADDITION

Mine	Test No.	Effluent pH	TDS	Ag	As	Be	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	Zn
Norton	N-1 (Raw)																	
	Influent	2.8	997	.013	DL	.007	.237	.227	.411	40.3	.072	2.43	4.86	.004	DL	DL	DL	.888
	Effluent	2.8	951	DL	DL	.007	.006	.017	.876	41.8	.080	2.19	.275	DL	DL	DL	DL	.610
	N-2																	
	Influent	9.4	979	.005	DL	.008	.007	.020	.142	37.8	DL	2.31	.294	DL	DL	DL	DL	.617
	Effluent	9.4	993	DL	DL	DL	.056	.062	.066	.756	DL	.006	.058	DL	DL	DL	DL	.065
	N-3 (spiked)																	
	Influent	6.3	1100	.023	DL	.009	2.50	2.54	3.20	40.4	.790	4.73	2.78	7.0	DL	DL	DL	3.43
	Effluent	6.3	1100	DL	DL	DL	.686	.077	.084	1.03	.410	3.47	.960	.029	DL	DL	DL	.167
	N-4 (spiked)																	
	Influent	8.3	983	.013	DL	.009	.015	.023	.146	36.4	.655	2.33	.317	.002	DL	DL	DL	.641
	Effluent	8.1	1000	DL	DL	DL	DL	.008	DL	1.38	DL	.500	.066	DL	DL	DL	DL	.012
	N-5																	
	Influent	8.2	1020	.009	DL	.011	.009	.023	.242	54.4	.615	2.82	.358	DL	DL	DL	DL	.780
	Effluent	8.0	989	.006	DL	DL	.020	.013	.005	1.94	.110	.439	.080	DL	DL	DL	DL	.025
	N-6 (spiked)																	
	Influent	8.1	1140	.015	DL	.009	2.93	2.99	3.74	37.4	.750	5.23	3.18	8.5	DL	DL	DL	3.99
	Effluent	8.0	1090	.010	DL	DL	.210	.091	.093	.821	.625	2.12	.312	.037	DL	DL	DL	.095
	Detection Limits	---	---	.005	.005	.001	.005	.005	.005	.005	.001	.005	.005	.001	.005	.010	.002	.002

Table VII-7 (Continued)

SUMMARY OF TEST RESULTS FOR METALS REMOVAL (mg/1) BY BPT AND FLOCCULANT ADDITION

Mine	Test No.	Effluent pH	TDS	Ag	As	Be	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	Zn
Holly-wood	Raw	3.5	775	.022	DL	.006	.020	.040	.019	46.9	DL	1.33	.376	.010	DL	DL	DL	.521
	H-1																	
	Influent	7.0	881	.009	DL	.008	.022	.057	.033	58.0	DL	1.60	.481	DL	DL	DL	DL	.668
	Effluent	7.4	839	.008	DL	DL	.006	.017	.017	1.13	DL	.161	.072	DL	DL	DL	DL	.027
	H-2 (spiked)																	
	Influent	8.7	719	.011	DL	.006	3.01	2.66	2.79	33.3	1.20	34	3.38	4.8	DL	DL	DL	2.78
	Effluent	8.8	733	.020	DL	DL	.084	.089	.082	.803	.234	.179	.14	.040	DL	DL	DL	.076
	H-3																	
	Influent	8.4	637	.008	DL	.004	.014	.033	.023	38.2	DL	1.15	.305	DL	DL	DL	DL	.430
	Effluent	8.5	636	DL	DL	DL	DL	.019	DL	1.29	DL	.120	.074	DL	DL	DL	DL	.018
	H-4 (spiked)																	
	Influent	7.5	829	.010	DL	.008	3.16	2.82	2.93	39.4	DL	3.59	3.60	4.70	DL	DL	DL	2.99
	Effluent	7.6	891	.013	DL	DL	.220	.118	.105	1.29	.005	1.35	.414	.046	DL	DL	DL	.106
	H-5																	
	Influent	9.5	799	.011	DL	.008	.018	.039	.016	57.2	DL	1.59	.437	DL	DL	DL	DL	.625
	Effluent	9.5	822	.014	DL	DL	DL	.021	.006	.785	DL	.040	.079	DL	DL	DL	DL	.020
	H-6 (spiked)																	
	Influent	9.6	1060	.024	DL	.009	3.15	2.81	2.90	47.0	1.07	3.84	3.65	4.2	DL	DL	DL	3.04
	Effluent	9.6	1000	DL	DL	DL	.029	.048	.023	.351	.151	.060	.118	.015	DL	DL	DL	.017
	H-7																	
	Influent	9.2	846	DL	DL	.009	.019	.043	.015	50.1	DL	1.42	.409	DL	DL	DL	DL	.565
	Effluent	9.2	864	DL	DL	DL	DL	.017	DL	.534	DL	.026	.075	DL	DL	DL	DL	.017
	H-8 (spiked)																	
	Influent	9.6	980	.006	DL	.009	3.11	2.83	2.90	51.1	.715	3.95	3.67	4.50	DL	DL	DL	3.07
	Effluent	9.7	1000	DL	DL	DL	.024	.047	.022	.395	DL	.041	.109	.011	DL	DL	DL	.023
	H-9																	
	Influent	9.7	879	.017	DL	.004	.015	.042	.015	48.9	DL	1.40	.401	DL	DL	DL	DL	.558
	Effluent	9.4	831	.013	DL	DL	DL	.019	DL	.477	DL	.027	.085	DL	DL	DL	DL	.008
	H-10 (spiked)																	
	Influent	10.2	1090	.022	DL	.005	2.93	2.72	2.79	45.9	2.82	3.74	3.56	5.5	DL	DL	DL	2.92
	Effluent	10.0	1030	.014	DL	DL	.024	.043	.026	.306	.819	.032	.104	.008	DL	DL	DL	.017
Detection Limits		---	---	.005	.001	.001	.002	.005	.001	.005	.005	.005	.005	.001	.005	.010	.002	.002

Table VII-7 (Continued)

SUMMARY OF TEST RESULTS FOR METALS REMOVAL (mg/1) BY BPT AND FLOCCULANT ADDITION

Mine	Test No.	Effluent pH	TDS	Ag	As	Be	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	Zn
Will Scarlet	Raw	2.03	19100	.241	DL	.175	.603	.461	.246	10.50	.628	183	7.27	.012	DL	DL	DL	31.6
	S-1																	
	Influent	9.6	2650	.168	DL	.137	.523	.431	.208	1220	DL	221	6.08	DL	DL	DL	DL	22.6
	Effluent	9.75	2920	.085	DL	.045	.196	.178	.081	311	DL	61.8	2.36	DL	DL	DL	DL	8.66
	S-2 (spiked)																	
	Influent	10.5	3250	.258	.017	.272	4.31	3.73	3.49	1980	.121	11.9	4.15	DL	DL	DL	DL	39.3
	Effluent	9.8	2610	.158	DL	DL	.051	.097	.082	.809	.013	.283	DL	DL	DL	DL	DL	.059
	Detection Limits	---	---	.005	.005	.001	.001	.002	.005	.005	.001	.005	.005	.001	.005	.010	.002	.002

Hollywood and Will Scarlett would be redundant and hence were not conducted.

Excluding the data from tests S-3 through S-6, means are presented in Table VII-8 for each of the final effluent metals concentrations (quantifying non-detected values as 1/2 the detection limit). These values represent achievable effluent limitations for acid mine drainage from deep and surface facilities through the application of BPT and flocculant addition technology.

Additional treatability analyses have been conducted by the Agency at the Crown, West Virginia site for polymer addition; results indicate that certain priority metals (Ni, Cu, Cr, and Se) are effectively reduced (2). Other studies have also confirmed the suspended solids and metals reductions documented above (16, 24, 25, 26, 27, 28).

In cases where settling ponds are at remote locations, construction of access roads and power lines will be necessary to install and maintain polymer feed equipment. The installation of chemical handling equipment, tanks, access roads, land, and power lines in remote areas could exacerbate coal mining production problems, particularly for small mines. Costs for those items are presented in the next section of this report. In some cases where ponds are difficult to access or lack electricity, gravity feed systems (used in one Western coal mine visited) or diesel generators can be employed.

Filtration

Filtration is used as a suspended solids and metals removal technology. Filter systems are usually located downstream of primary gravity settlers, lime precipitation units, or polymer addition equipment. Filtration is accomplished by the passage of water through a physically restrictive medium with resulting entrapment of suspended particulate matter. Filtration is a versatile method in that it can be used to remove a wide range of suspended particle sizes.

Filtration processes can be placed in two general categories: (1) surface filtration devices, including microscreens and diatomaceous-earth filters; and (2) granular-media filtration, such as rapid sand filters, slow sand filters, and mixed media filters. For application to coal mine wastewaters, granular mixed media filtration systems are most suitable.

Granular media filtration utilizes a variety of mechanisms including straining, interception, impaction, sedimentation of backwash, and adsorption for suspended solids removal. Filters are most often classified by flow direction and type of filter

Table VII-8

MEAN FINAL EFFLUENT CONCENTRATIONS (mg/l) FOR UNSPIKED AND SPIKED SAMPLES

Metal	Unspiked		Spiked	
	Mean	Standard Deviation	Mean	Standard Deviation
Ag	.009	.006	.023	.045
As	.0025	0	.0025	0
Be	.0005	0	.001	.002
Cd	.0252	.060	.150	.203
Cr	.0581	.0622	.072	.0263
Cu	.0114	.0197	.0636	.043
Fe	2.28	3.79	2.96	7.04
Hg	0.0114	0.0327	.183	.280
Mn	.612	.986	1.55	1.60
Ni	.084	.023	.273	.263
Pb	.0005	0	.019	.018
Sb	.0025	0	.0025	0
Se	.005	0	.001	0
Tl	.001	0	.001	0
Zn	.0642	.134	.059	.0521

bed. Downflow, multimedia filters would probably find the widest application to both acid and alkaline coal mine wastewaters. In such a system, influent is piped to the top of the filter and by gravity or external pressure percolates through the bed before discharge or further treatment.

Maximum loading of the filter is determined either by a prescribed permissible head loss (the pressure drop across the filter) or a ceiling level of suspended solids in the filtered effluent. When these conditions occur, the filter is backwashed and air-scrubbed to clean the bed, and the wash water disposed of in an acceptable manner, usually by settling and return to the head of the treatment plant.

Various combinations of media, including sand, gravel, garnet, activated carbon, anthracite coal, and ilmenite, can be used in a filtration system. These materials represent a wide distribution of specific gravities and grain sizes. Total media depths typically range from 50 cm to 250 cm, with feedwater flux rates of 2 to 30 gallons per minute per square foot of cross-sectional area, with 10 gpm per square foot typical.

Whenever possible, designs should be based on pilot filtration studies of the actual wastewater. Such studies are the best way to assure: (1) representative cost comparisons between different filter designs capable of equivalent performance (i.e., quantity filtered and filtrate quality); (2) selection of optimal operating parameters, such as filter rate, terminal head loss, and run length for a given medium application; (3) definite effluent quality performance for a given medium application; and (4) determination of the effects of pretreatment variations. Ultimate clarification of filtered water will be a function of particle size, filter medium porosity, filtration rate, and other variables.

The technology is proven in both industrial and municipal applications and is cost effective in relation to other technologies when reductions to 10 mg/l TSS and less and very low levels of suspended metals are to be achieved. A major question in application to coal mine wastewater is the potential for gypsum fouling/blinding when lime is used for neutralization and/or precipitation of AMD. Gypsum ($CaSO_4 . 2H_2O$) is formed when calcium ions liberated by the dissolution of lime (CaO) combine at alkaline pH with sulfate ions. This substance will deposit on surfaces throughout the treatment system. When this material deposits on the granular media pores, water is impeded from passing across or through the filtration apparatus. This phenomena is called fouling or blinding. The problem can be abated by proper dosage of lime, recycle of sludge or use of a different neutralizing chemical. To examine the levels of suspended solids and toxic removal potential achieved by filtration technology, a treatability study was instituted by the Agency at two mines, both exhibiting normally acid mine drainage (24, 25).

The first testing program, conducted on BPT-treated acid mine drainage from a deep mine in Pennsylvania, consisted of bench scale jar tests, dual media filtration tests and backwash settling tests at the coal mine site. In addition to determination of achievable removal of suspended matter, an evaluation of possible effects of fouling caused by gypsum or excess lime was carried out. Further, a number of filtration tests were run with addition of different polyelectrolytes to ascertain their effect on filter performance. Composite samplers were used to track filter progress.

Initial flux rates for each test were established at 20 gpm per square foot of filter area. The influent to the test unit was clarifier effluent from the acid mine drainage treatment plant. Test parameters for each test run are summarized in Table VII-9. No filter test runs exhibited a significant flow reduction, including a test of 43 hours duration (test no. 9). Effluent suspended solids averages were always below 15 mg/l and, in many cases, less than 10 mg/l. This level was independent of the duration of the test run. At the end of each filter test run, the filter media were cleaned by a combination of air and water backwash. A backwash period of 10 minutes was found to be sufficient in each case to regenerate the filter.

Analytical data for the priority metals are summarized in Table VII-10. Priority metals in the clarifier effluent used as influent to the filtration apparatus were very low. In addition, no spiking of effluent for treatment was conducted. As a result, quantitative prediction of priority metals removal is not possible. Metal levels in many influents were not detectable and in no case did a priority metal have a filter effluent concentration of greater than .012 mg/l. Reductions of iron to .75 mg/l average effluent concentration from 2.8 mg/l average influent, and reduction of manganese to .063 mg/l from .17 mg/l average were achieved.

Treatability information is currently being collected at one additional facility known to have substantial gypsum formation to assess the effect of this substance on filter performance.

ALKALINE MINE DRAINAGE

Current Treatment Technology

Mines exhibiting alkaline drainage supply a majority of U.S. coal production. Raw wastewaters from these mines are generally characterized by very low metals levels and are pH neutral or

Table VII-9

SUMMARY OF FILTRATION TESTS PERFORMED

Test No.	Polymer Added (mg/1)	Suspended Solids (mg/1)						Initial pH	Final pH
		Influent			Effluent				
		Min.	Max.	Ave.	Min.	Max.	Ave.		
1	(none)	10.2	27.4	12.8	1.2	9.2	2.6	9.2	9.2
2	-	--	--	13.6	--	--	1.4	9.4	9.2
3	-	9.9	17.8	13.3	1.6	7.0	3.0	9.4	9.1
4	-	--	--	17.4	--	--	3.8	9.5	9.1
5	-	16.2	38.8	27.8	2.8	11.4	7.8	9.3	9.1
6	-	16.4	40.6	28.6	6.1	16.1	11.0	9.2	9.2
7	1[a]	14.4	34.8	23.6	1.0	8.6	5.5	9.5	9.2
8	1[a]	--	--	21.2	--	--	5.2	9.4	9.1
9	-	--	--	20.2	--	--	7.0	9.0	8.8
10	1[b]	13.6	29.4	22.2	<1.0	13.6	7.3	9.4	9.1
11	1[b]	19.0	48.2	33.6	9.9	17.3	14.1	9.2	9.2
12	-	17.6	39.2	24.9	3.4	10.2	6.6	9.5	9.3
13	-	--	--	20.0	--	--	10.4	9.7	8.7
14	1[c]	17.8	43.0	27.8	<1.0	10.6	6.5	9.4	9.3
15	1[c]	--	--	11.4	--	--	10.2	9.2	9.0
16	-	16.2	99.4	24.0	7.0	16.4	9.8	9.8	9.5
17	-	--	--	15.4	--	--	2.8	9.9	9.7

Notes: [a]Dowell 144
[b]Magnifloc 1820A
[c]Calgon L670E

Table VII-10

ANALYTICAL RESULTS FROM FILTRATION TREATABILITY STUDY
(in ug/l unless noted)

Test No.	pH (units)	TDS (mg/l)	Ag	As	Be	Cd	Cr	Cu	Pb	Fe	Hg	Mn	Ni	Sb	Se	Tl	Zn
1																	
Influent	9.3	1400	10	<3	<1	<8	16	10	<2	1900	<.5	120	<3	<5	<3	<3	34
Effluent	9.3	1400	3	<3	<1	<8	4	6	<2	110	<.5	16	<3	<5	<3	<3	12
2																	
Influent	9.4	1400	8	<3	<1	<8	10	8	<2	1900	<.5	130	<3	<5	<3	<3	27
Effluent	9.4	1400	7	<3	<1	<8	10	9	<2	260	<.5	28	<3	<5	<3	<3	23
3																	
Influent	9.2	1350	14	<3	<1	<8	16	19	<2	280	<.5	43	<3	<5	<3	<3	22
Effluent	8.5	1400	15	<3	<1	<8	18	13	<2	2000	<.5	130	<3	<5	<3	<3	26
4																	
Influent	9.5	1400	11	<3	<1	<8	15	12	<2	2300	<.5	150	<3	<5	<3	<3	28
Effluent	9.4	1400	11	<3	<1	<8	16	13	<2	330	<.5	39	<3	<5	<3	<3	18
5																	
Influent	9.3	1400	16	<3	<1	<8	22	14	<2	3100	<.5	210	<3	<5	<3	<3	39
Effluent	9.1	1400	16	<3	<1	<8	22	13	<2	610	<.5	73	<3	<5	<3	<3	22
6																	
Influent	9.5	1400	23	<3	<1	9	26	17	<2	3200	<.5	210	<3	<5	<3	<3	44
Effluent	9.4	1400	21	<3	<1	10	26	16	<2	850	<.5	69	<3	<5	<3	<3	27
7																	
Influent	9.7	1400	28	<3	7	<8	17	<1	<2	3000	<.5	180	<3	<5	<3	<3	24
Effluent	9.4	1360	36	<3	7	<8	23	4	<2	690	<.5	54	<3	<5	<3	<3	12
8																	
Influent	9.6	1400	34	<3	7	<8	21	5	<2	3400	<.5	190	<3	<5	<3	<3	56
Effluent	9.7	1400	33	<3	7	<8	21	7	<2	860	<.5	55	<3	<5	<3	<3	12
9																	
Influent	8.9	1420	4	<3	1	<8	11	8	<2	3400	<.5	205	<3	<5	<3	<3	27
Effluent	8.9	1430	<2	<3	8	<8	<3	<1	<2	1300	<.5	98	<3	<5	<3	<3	11
10																	
Influent	9.3	1440	<2	<3	8	<8	<3	<1	<2	2600	<.5	160	<3	<5	<3	<3	16
Effluent	8.8	1430	<2	<3	7	<8	<3	<1	<2	790	<.5	55	<3	<5	<3	<3	8

Table VII-10 (Continued)

ANALYTICAL RESULTS FROM FILTRATION TREATABILITY STUDY
(in ug/l unless noted)

Test No.	pH (units)	TDS (mg/l)	Ag	As	Be	Cd	Cr	Cu	Pb	Fe	Hg	Mn	Ni	Sb	Se	Tl	Zn
11																	
Influent	9.3	1440	<2	<3	8	<8	<3	<1	<2	4100	<.5	250	<3	<5	<3	<3	26
Effluent	9.2	1440	<2	<3	7	<8	<3	<1	<2	1100	<.5	77	<3	<5	<3	<3	7
12																	
Influent	9.5	1350	<2	<3	8	<8	<3	<1	<2	2700	<.5	160	<3	<5	<3	<3	14
Effluent	9.4	1340	<2	<3	7	<8	<3	<1	<2	880	<.5	57	<3	<5	<3	<3	<3
13																	
Influent	9.7	1380	<2	<3	8	<8	<3	<1	<2	3200	<.5	178	<3	<5	<3	<3	17
Effluent	8.6	1360	<2	<3	7	<8	<3	<1	<2	1300	<.5	97	<3	<5	<3	<3	5
14																	
Influent	9.7	1410	<2	<3	8	<8	4	91	<2	3200	<.5	186	<3	<5	<3	<3	70
Effluent	9.5	1390	<2	<3	7	<8	2	2	<2	693	<.5	61	<3	<5	<3	<3	4
15																	
Influent	9.8	1400	<2	<3	8	<8	2	<1	<2	4100	<.5	223	<3	<5	<3	<3	23
Effluent	9.6	1400	<2	<3	7	<8	1	<1	<2	1400	<.5	83	<3	<5	<3	<3	5
16																	
Influent	9.7	1380	7	<3	8	<8	9	7	<2	2800	0.7	170	<3	<5	<3	<3	16
Effluent	9.4	1370	8	<3	7	<8	9	7	<2	950	1.0	57	<3	<5	<3	<3	3
17																	
Influent	9.6	1390	9	<3	8	<8	10	8	<2	2500	1.0	130	<3	<5	<3	<3	13
Effluent	9.6	1380	5	<3	7	<8	7	6	<2	430	1.0	30	<3	<5	<3	<3	<3
Average																	
Influent	---	1400	10	1.5	4.8	4.3	10.9	11.9	1	2800	.3	170	1.5	2.5	1.5	1.5	29
Effluent	---	1400	9.5	1.5	4.7	4.4	9.8	5.8	1	750	.5	63	1.5	2.5	1.5	1.5	12

slightly alkaline. Alkaline surface mines can contain high sediment loading caused by precipitation and runoff, whereas alkaline underground mines are most often low in suspended solids. Many mines with alkaline drainage can discharge the raw water without any treatment. However, most mines will have a pond or pond system installed to contain or treat runoff resulting from rainfall. Aside from precipitation and the ensuing sediment laden runoff, the major exception to mines that can normally discharge without treatment is for those mines located in geological strata containing fine clays. These colloidal clays are difficult to settle without coagulant aids. If fine clays are prevalent, chemical flocculant addition may be required to comply with BPT limitations. This, however, is an infrequent situation in the industry. Figure VII-10 depicts a typical BPT treatment system for alkaline drainage. The settling facility is identical to the sediment pond or mechanical clarifier discussed under the previous acid mine drainage subsection. Ponds installed to comply with rainfall provisions are discussed later in this section.

Candidate Treatment Technologies

Technologies applicable to alkaline mines are similar to treatment options discussed under acid mine drainage for BPT treated wastewaters. The reader is directed to the Acid Mine Drainage Candidate Treatment Technology subsection for a detailed discussion of the technologies.

PREPARATION PLANTS

Current Treatment Technologies

Wastewater from coal preparation plants, as discussed in Section V, originates from preparation plant coal separation and cleaning equipment, such as jigs, washers, froth flotation units, and wet cyclones. The water is high in coal fines which are removed prior to discharge or reuse. Economic and environmental incentives often dictate that some portion of this effluent water be recycled for plant use. Some plants operate under total recycle while others recycle only a fraction or none at all. The remainder is discharged after appropriate treatment, usually consisting of some type of sedimentation technology. This will remove the coal fines which are present as suspended solids.

Figure VII-11 illustrates a typical treatment scenario for preparation plant wastewaters. The slurry stream generated by the preparation plant usually contains fine coal refuse as a waste product from the coal cleaning process. The refuse contained in the slurry is usually 0.10 in (approximately 2.50 mm) and finer in size and frequently contains less than 10 percent by weight

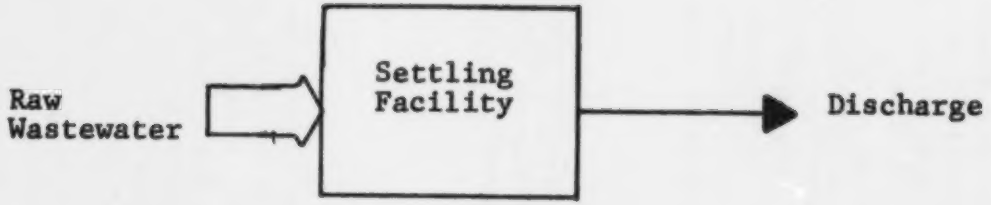

Raw Wastewater
Settling Facility
Discharge

Figure VII-10
TYPICAL BPT TREATMENT CONFIGURATION FOR ALKALINE MINE DRAINAGE

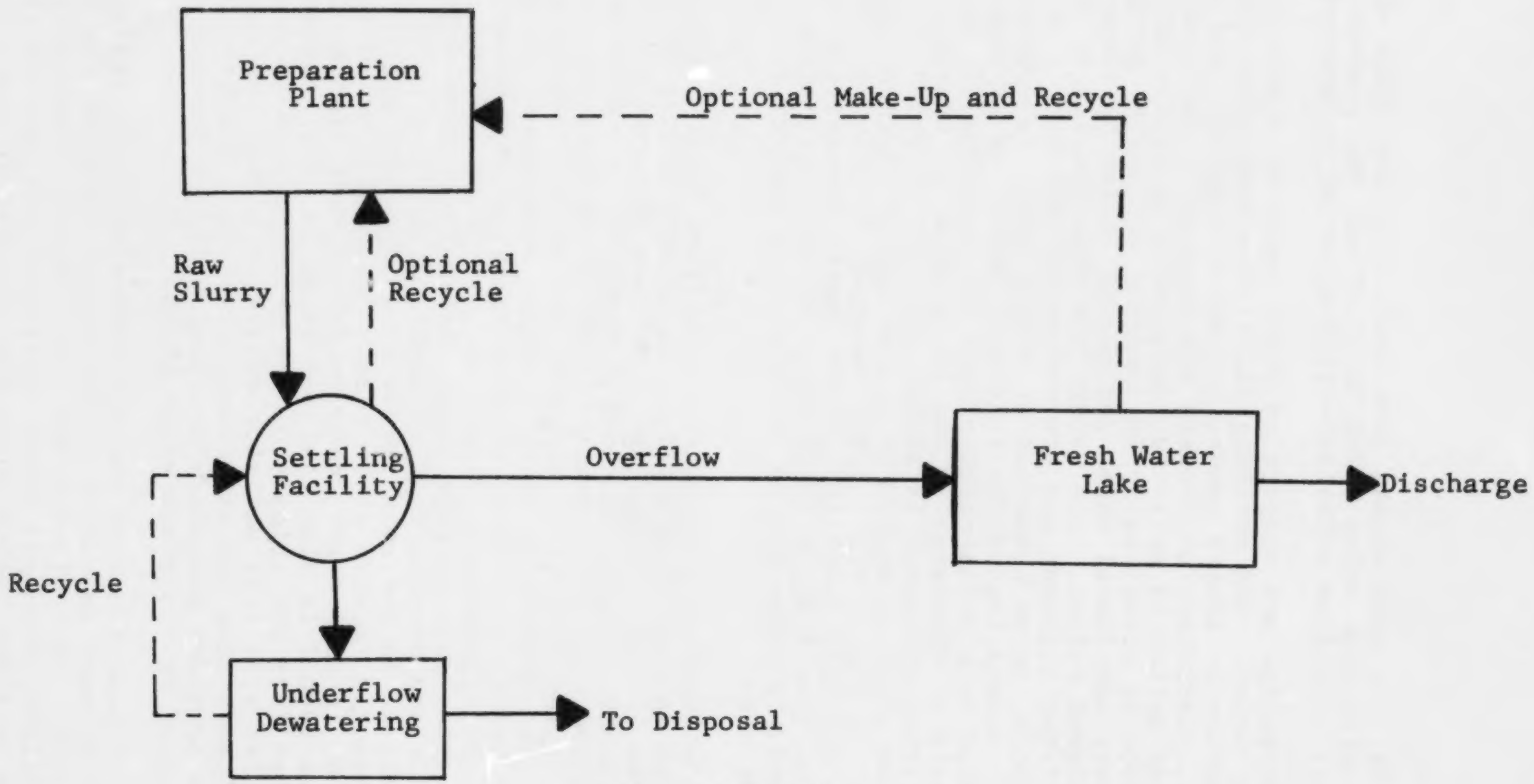

Preparation Plant
Optional Make-Up and Recycle
Raw Slurry
Optional Recycle
Settling Facility
Overflow
Fresh Water Lake
Discharge
Recycle
Underflow Dewatering
To Disposal

Figure VII-11

TYPICAL BPT TREATMENT CONFIGURATION FOR PREPARATION PLANT WASTEWATER solids. In many cases, fine coal, clay and other mineral particles with size below 0.004 in (0.10 mm) are present. In some cases, very fine colloidal-sized material is present.

These solids are removed to allow reuse or discharge of the clarified water. The settling facilities most often used are sedimentation or slurry ponds, or, where adequate land is not available, clarifiers/thickeners are frequently employed. Where the latter option is selected, dewatering by vacuum or pressure filtration is occasionally implemented within the industry to recover additional water and permit easier handling of the dewatered refuse. The water from this process is recycled to the clarifier influent and the refuse is hauled to a disposal site, a borehole, or an abandoned or active pit. In Appalachian facilities, dewatering of the thickener underflow is commonly accomplished in a sedimentation pond for settling of the solids and recycle or discharge of the basin decant. Overflow from the clarifier/thickener is either directly recycled to the preparation plant or routed to a pond system (termed a "fresh water lake" in Figure VII-11) for eventual recycle or discharge. In many existing facilities, this latter alternative of drawing makeup from a fresh water basin is often preferred to provide a dependable water source of consistent quality for preparation plant use.

Many midwestern and western facilities employ sedimentation basins in lieu of clarifiers to provide solids removal for the refuse slurry. Basins are sometimes designed for the life of the preparation plant, but more frequently, a number of ponds are required over the operating life of the cleaning facility. As one slurry pond is silted out, slurry is diverted to a new basin. The old pond can be dredged and/or reclaimed. These sedimentation basins will often receive drainage from areas associated with the preparation plant, such as disturbed areas ancillary to the site, coal storage piles, and refuse piles. The characteristics and treatment of effluents from these three sources are discussed in the next subsection. The pond system will also frequently receive storm runoff drainage from undisturbed areas, which, in some cases, can consist of vast tracts of land. This storm runoff is also analyzed later in this section. Decant routed from the primary slurry settling pond is commonly commingled with this undisturbed area drainage and raw or treated effluents from the associated areas in a fresh water lake. This lake provides secondary settling prior to recycle of water required by the preparation plant.

The suspended solids removal technology selected by mine operators is very dependent on the region in which the mine is located. In Applachia and other regions where steep terrain is prevalent, thickeners and clarifiers are usually installed rather than settling basins to handle preparation plant slurries.

Those plants using a clarifier often use a coagulant aid to assist in agglomerating fine solids, resulting in greater settling rates of solids. Preparation plants that employ settling ponds for suspended solids removal do not usually inject chemical aids but instead rely on the longer retention times available to provide sufficent settling.

Candidate Treatment and Control Technologies - Existing Sources

Control technologies are particularly applicable to preparation plant wastewaters in the abatement of pollution from these sources. This includes consideration of a no discharge of pollutants requirement that would require recirculation of all water from a system treating wastewater from a preparation plant water circuit.

Total Recycle Option

To properly evaluate this option for existing sources, an examination of the definition of preparation plant wastewater is essential. For the remainder of this report, "preparation plant wastewater" is defined as any wastewater which results from processing a stream of coal to remove ash forming constituents. This wastewater consists of the following:

1. Water purposely brought into contact with run-of-mine coal to clean the coal,

2. Water collected in the waste sump resulting from spills or cleanup within the preparation plant boundaries, and

3. Runoff resulting from precipitation which enters the preparation plant wastewater treatment system.

Thus, the zero discharge requirement would effectively disallow the discharge of any pollutant-bearing water that stems from or contacts process water from the preparation plant.

To assist in the analysis of this issue, Figure VII-12 depicts the various flows into and out of the preparation plant.

The types of flow streams entering the water circuit are shown on the left side of the block diagram and flows exiting the system are shown on the right side. The various sources and losses of water in the system will be discussed below in an effort to evaluate the requirements for attainment of total recycle for the preparation plant water circuit.

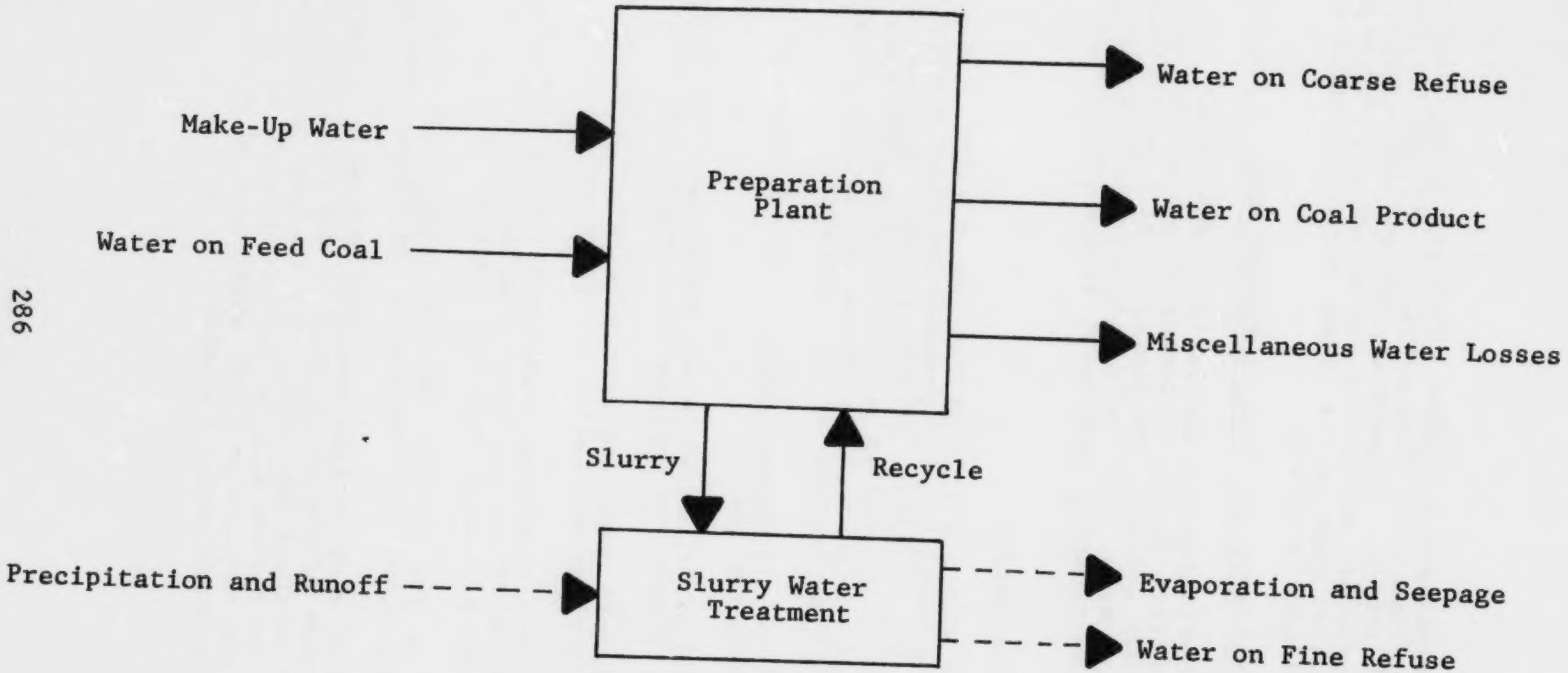

Make-Up Water
Water on Feed Coal
Preparation Plant
Water on Coarse Refuse
Water on Coal Product
Miscellaneous Water Losses
Slurry
Recycle
Precipitation and Runoff
Slurry Water Treatment
Evaporation and Seepage
Water on Fine Refuse

Figure VII-12

WATER SOURCES AND LOSSES IN A PREPARATION PLANT WATER CIRCUIT

Water sources include:

1. Makeup Water. Water from sources external to the preparation plant and slurry water systems are almost always needed to meet the feed water requirements of the plant after using the water recycled from slurry treatment. Typical sources might be surface impoundments, mine drainage, well water, or drainage from preparation plant associated areas. This water should be neutral or basic to minimize corrosion problems and be relatively low in suspended solids content to avoid nozzle fouling in the plant. The volume of makeup water from sources external to the preparation plant water circuit may be zero if the slurry treatment system has sufficient capacity to store large volumes of water. In general, however, implementation of a zero discharge requirement would necessitate a makeup water source that can be throttled to balance the system.

2. Water on the Surface of Feed Coal. The coal entering the preparation plant usually has some water on the surface of the coal. This water results from dust suppression sprays in underground mined coal or from ground water in wet surface or underground mines. The raw coal also receives water as a result of precipitation falling on storage piles or on the coal as it is transported to the plant.

3. Precipitation and Runoff. The quantity of water entering the system from precipitation and runoff is governed by design and climatological factors which are both site specific. A slurry treatment system consisting of a thickener and filtration of the underflow receives precipitation only on the surface of the thickener. The amount of precipitation entering a pond system is related directly to the drainage area of the pond or ponds. The amount of runoff entering from areas adjacent to the pond system can be controlled at the design phase or as a retrofit procedure by using diversion ditching and diking as required to control inflow.

Water losses include:

1. Moisture on the coal product. This moisture leaves a preparation plant as residual water after having undergone some form of mechanical and/or thermal coal drying. The degree to which the coal material is dried is usually determined by what is necessary to achieve purchaser specifications and/or the avoidance of excessive transportation costs. The amount of water leaving with the coal will most often be greater than that entering with it since the cleaning process involves a size reduction with the attendant increase in surface area. This increase in porosity due to smaller grain sizes enhances water retention.

2. Water on Coarse Refuse. The cleaning process is designed to remove material that either does not contribute to the end use of the coal or has some deleterious effect on the use of the coal. These materials are removed as refuse by processes in the preparation plant. The bulk of this refuse leaves the plant as a surface-saturated solid after mechanical dewatering. It is dry enough to allow handling by truck or conveyor to a disposal site. The large size of this refuse makes use of wet disposal impractical. The volume of this coarse refuse will be a function of the amount of non-coal components in the plant feed and the efficiency of the separation. The total amount of water leaving the system by this route will be dependent on the amount of refuse as well as the relative size of the refuse.

3. Miscellaneous Water Lost (Drying and Evaporation). In some cases, thermal drying of the coal is required to meet product specifications. Usually, thermal drying is primarily used for the fine coal fraction. In this process, the surface moisture in the coal is reduced by evaporative losses. Water is also lost by evaporation in the plant, particularly at locations where water sprays are used in processing. Usually the water removed from the system as a result of drying and evaporation is not large compared to the total plant water requirement.

4. Evaporation and Seepage from Slurry Water Treatment. The volume and importance of these losses from the system will be a function of the design of the system as well as site specific hydrologic conditions. For example, if the slurry water treatment consists of a thickener and underflow dewatering, then seepage is nonexistent. Evaporation, although still dependent on local climatic factors, is limited to the surface area of the thickener. On the other hand, slurry water treatment by sedimentation in a pond system can result in major losses by evaporation and seepage depending upon design and maintenance of the system (e.g., surface area, lining, etc.).

5. Fine Refuse Moisture. Generally, a preparation process is designed to minimize the production of fines while achieving the desired coal quality improvement. Therefore, the fine solids which can be removed from the slurry by some combination of sedimentation (usually in mechanical thickeners or settling impoundments) and filtration usually represent a relatively small proportion of the feed material. After the fine solids have been removed in the settling facility from the bulk slurry, they will retain considerable water. Fine solids can be dewatered by filtration of the thickener underflow, and will often contain about 25 percent water by weight. The fine solids removed by sedimentation in ponds will, of course, retain greater amounts of water.

As indicated above, losses from water on the coal product and coarse refuse, as well as internal evaporative losses are insignificant in comparison to the total water flow in the plant. Closing the water circuit will primarily involve recycling of preparation plant effluents as makeup to the facility. However, the wastewater leaving the preparation plant as slurry is not suited for direct reuse in the preparation plant because of its fine solids content.

The slurry treatment process must prepare water for recycle that is relatively free of suspended solids so that its solids carrying capacity is restored for removal of similar material in the preparation plant. Solids even in fine sizes and low concentrations can cause long term maintenance problems as a result of excessive pump and piping wear. Nozzle plugging is an additional maintenance problem for washing operations within the plant. The reuse for screen spray and wash water of thickener overflow with suspended solids less than 100 ppm has been reported. Slurry treatment must also provide recycle water which is neutral or alkaline to minimize corrosion of the process equipment.

Two primary issues can be delineated regarding a no discharge requirement. First, a total recycle system must provide sufficient water to meet process requirements while taking into account the water losses previously discussed. Second, the feasibility of segregating preparation plant wastewater from other wastewater must be assessed. Both of these factors are primarily design considerations.

A survey was conducted in cooperation with the National Coal Association in 1980 of its member companies to collect data and information specifying the design of their preparation plant slurry treatment systems. Eighty-eight member producer companies of the NCA were canvassed for profile information and water management data. These companies operate approximately 292 preparation plants. One hundred and fifty-two of these (52 percent), representing about 24 percent of the entire preparation plant industry, responded to the survey. Results from the responding facilities indicate that approximately 34 percent are currently achieving zero discharge of preparation plant wastewater. This suggests that certain facilities have adequately addressed the two issues outlined above. Other facilities have a system design that provides for a sufficiently large drainage area to continually supply preparation plant makeup water needs. Such systems resolve the first issue but are susceptible to voluminous amounts of discharge during rainfall. Plants that obtain water from this type of system would have to provide adequate freeboard in their slurry basins to accomodate the storm flows. A second way to comply would be to install a clarifier/thickener with underflow dewatering, thus obviating the need for the pond system. A third alternative is to install diking and diversion ditching around the pond system and drawing makeup water from a new source. This third alternative may also require installation of new facilities to treat the diverted runoff, particularly if acidic refuse and coal pile drainage is involved. These alternatives are shown schematically in Figures VIII-18 and VIII-19 in Section VIII.

If a facility already has a clarifier installed, changes would be confined to recycling all decant to the preparation plant and dewatering the underflow solids. This option is depicted schematically in Figure VIII-20 of Section VIII. Redesign of the clarifier or additon of equipment for chemically aided solids settling may be required to provide water of suitable quality as makeup water. Many facilities already have this flocculant addition equipment in place with their clarifiers.

Total recycle with no discharge is a technically achievable control technology to reduce the discharge of pollutants from coal preparation processes into the environment. This is particularly true for new sources where water handling strategies can be planned from the design phase. The costs associated with implementation of this alternative are presented and discussed in Section VIII.

Flocculant Addition

Flocculant addition is also a candidate BAT option for preparation plant wastewaters. Important factors characterizing this technology were previously discussed for mine drainage and will not be repeated here.

Filtration

Preparation plant wastewaters are readily amenable to this type of treatment. Gypsum is rarely evident in the normally alkaline effluents. Further, metals, if present, are in the suspended state and are thus removed by filtration. Application of this technology is feasible for both clarifier and sediment basin effluents. Achievable levels are documented in the mine drainage section.

Other Technologies

Reverse osmosis, ion exchange, electrodialysis, and sulfide precipitation are technologies applicable for dissolved solids removals. Alkaline effluents are characteristically low in undesirable and toxic dissolved metals, and thus these technologies are not considered for preparation plant wastewaters. Activated carbon and ozonation are fouled by high suspended solids, rendering them ineffective for these types of effluents. Moreover, their principal application is for a dissolved compound at a low pH value, none of which are expected in preparation plant discharges.

Candidate Treatment Technologies - New Sources

Two major options are considered for new source preparation plant discharges--a no discharge of pollutants requirement and a discharge with effluent standards achievable through application of the best available demonstrated treatment technology. The latter approach is identical to that discussed for existing sources and will not be repeated here. However, additional considerations are relevant for the no discharge requirement. First, design of a total recycle system is easily adopted for new sources. Segregation of other drainage from the preparation plant wastewater can be a design parameter of the system. Ponds can be located in topographical areas that do not receive large amounts of natural drainage. This will lessen the volume of storm runoff requiring diversion around the slurry treatment system. Second, if clarifier/thickeners are selected for settling, small emergency ponds can be provided to contain temporary imbalances in the water circuit arising from operational problems or exceedingly heavy precipitation on the clarifier surface. Thirdly, the achievement of zero discharge at facilities in each major coal producing region substantiate this option as the best available demonstrated technology. No fundamental technical reasons for inability to achieve this requirement for new sources have been identified. Costs for implementation of this option and of discharges employing filtration technology to polish the final effluent are presented in the next section.

PREPARATION PLANT ASSOCIATED AREAS

Current Treatment Technology

Drainage from these areas is a result of runoff from coal storage and refuse piles and other disturbed areas. This runoff has similar characteristics to untreated drainage from adjacent mines. The rulemaking published on 26 April 1977 (see 42 FR 21380) thus established limitations similar to those for active mine drainage; i.e., standards for pH, TSS, and iron (and manganese for drainage that is normally acidic prior to treatment). As a result, current treatment technology for this subcategory typically includes neutralization, aeration, and settling for acidic runoff and settling for alkaline runoff. In cases where site logistics permit, runoff is often commingled with mine drainage due to the cost advantages in joint treatment. Each of the technologies was discussed in detail in the mine drainage subsection and is not reiterated here.

Candidate Treatment Technologies

Drainage from preparation plant associated areas is often commingled for treatment with the preparation plant wastewaters. Establishment of a no discharge regulation for associated area runoff is infeasible due to the extremely wide variations in storm runoff. If such a requirement is proposed for preparation plant wastewaters in existing sources, associated area drainage would in most cases have to be segregated and treated separately. Because this wastewater is similar to mine drainage, the reader is referred to the discussion found in the Candidate Treatment Technologies portion of that subsection.

POST MINING DISCHARGES

Reclamation Areas

Current Treatment Technology

Areas under reclamation are defined as areas of land resulting from the surface mining of coal which has been returned to final contour and revegetation begun. Drainage from land that has been regraded after active mining is not currently subject to EPA regulations unless commingled with wastewater from the active mining area. OSM, under authority of SMCRA, has required that drainage from reclamation areas must be routed through a sedimentation pond. Therefore, operators have installed sedimentation ponds to treat this drainage until revegetation requirements are met and untreated drainage (influent to the ponds) meets the applicable state and federal water quality standards for the receiving stream (see 44 FR, 3 March 1979).

Candidate Treatment Technology

The Agency has conducted a sampling and analysis program under authority of Section 308 of the Clean Water Act to have 12 companies monitor influents and effluents at two ponds for each company. These ponds primarily receive drainage from areas undergoing revegetation, although some ponds also receive active mine drainage. Data from the first 10 months of the program are presented in Table V-9. Total suspended solids were found at widely varying levels, due partly to differences in particle size distribution delivered to the pond from the reclamation area. Settleable solids (i.e., suspended particles that will settle within one hour), however, are effectively controlled by these sediment ponds.

The data also demonstrate that concentrations of the toxic metals and iron and manganese in drainage from these areas are at or very near limits of analytical detection.

The number of ponds or other type of treatment required can be quite large. This is because the acreage under reclamation is often larger than the active area, especially as the surface mining project is developed. Reclamation in the East requires a minimum of five years and in the West a minimum of ten years, according to OSM criteria. The large number of ponds already in existence constrain the technology selection from a cost standpoint.

Underground Mine Discharges

Current Treatment Technology

Underground mines will often continue to discharge after cessation of coal removal from the mine. This drainage is similar in composition to the drainage that occurred during the active life of the mine, since the mechanism for generation is identical. No EPA limitations are currently established for these discharges. However, OSM standards require that this drainage be treated until either the discharge continuously meets OSM effluent limitations or the discharge has permanently ceased.

Technology to control these discharges is identical to that implemented for active mine drainage. For acid discharges, this includes neutralization, aeration, and settling. Alkaline discharges require only settling. Each of these has been extensively discussed and will not be repeated here.

Candidate Treatment Technology

Each treatment technology presented in the active mine drainage sections is also considered for this subcategory.

PRECIPITATION EVENTS

Precipitation events can make it infeasible to meet effluent limitations (see "Evaluation of Performance Capability of Surface Mine Sediment Basins" by Skelly and Loy, Engineers-Consultants, Harrisburg, Pennsylvania, July 1979). These events are often beyond the control of the coal operator; thus, some mechanism should exist to temporarily exempt the facility from compliance until "normal" conditions return. For the coal mining industry, precipitation is the prime cause of an excursion beyond the effluent standards, particularly for total suspended solids. This is because the vast tracts of land occupied by many surface coal mines receive substantial rainfall, particularly in the Appalachian coal region.

The original exemption for storm (or snowmelt events) was published at the time of BPT regulatory promulgation on 26 April 1977 (42 FR 21380). The exemption was provided for overflows from sedimentation ponds that were "designed, constructed, and maintained to contain or treat the discharges . . . which would result from a 10-year, 24-hour precipitation event . . .." Thus, the exemption was available regardless of the size of the hydrologic event. On 12 January 1979, the Agency promulgated new source performance standards for the coal mining category that contained a modified storm exemption. The modification included that: (1) the burden of proof was placed on the operator to demonstrate that the appropriate prerequisites to obtaining the exemption had been met, and (2) an exemption could only be granted if a 10-year, 24-hour or larger event (or snowmelt of equivalent volume) had actually occurred. On 2 April 1979, the exemption provided for existing sources was amended to be identical to the NSPS exemption. These actions met with substantial criticism and legal opposition by various industry trade groups, such that EPA withdrew its modified exemption provision and instituted the Skelly and Loy Study cited above to more clearly define sedimentation pond performance, particularly for those storms less than the 10-year, 24-hour event.

This study concluded that sediment pond efficiency during storm events is, to a large extent, dependent on site-specific factors. The inflow hydrograph (i.e., the volume of water delivered to a pond at any given moment during or immediately after a storm) of a given storm event, and the volume and concentration of sediment delivered, will depend in each case on, among other things, the soil erodibility, length and steepness of the terrain, and cover and management practices employed at a given watershed.

Moreover, the specific total suspended solids concentration in the effluent of a given sediment pond will depend on the particle size distribution of the solids delivered to the pond. As the Skelly and Loy study demonstrates, theoretical detention times on the order of 24 hours may not be sufficient to permit settling of fine, colloidal solids. Thus, even if all of the larger solids settle, TSS effluent concentrations can vary widely depending upon the amounts of fine material present in the influent. The particle size distribution of the sediment delivered at a particular site is thus a critical factor affecting effluent quality, and is largely beyond the control of the operator. This distribution will vary not only from site to site for a given storm event, but at the same site during the course of that storm (7).

These conclusions were verified by other available literature, including an EPA study entitled, "Effectiveness of Surface Mine Sedimentation Ponds" published in 1976. This study's central conclusion was that the sediment ponds which were properly utilized and maintained were measured to have high efficiencies of removal of suspended solids during the baseline sampling period. However, the efficiency of removal of suspended solids was measured to be much lower during the storm event (12). The report goes on to state that the lower efficiencies were primarily attributable to improper construction and maintenance of the ponds.

As a result of these investigations, on 28 December 1979 (44 FR 76788), the Agency rescinded its BPT and NSPS storm exemptions and promulgated what was essentially the original BPT exemption, with the burden of proof placed upon an operator and a requirement that the overflow had been caused by an actual hydrological event.

During the course of this rulemaking, the Agency instituted two studies to investigate the appropriateness of alternate limitations during the storm exemption period. The first study, incomplete as yet, is being conducted at eight mine sites in the eastern and western regions. Data from the second study at 22 surface mine sedimentation ponds were collected during baseflow and rainfall conditions to demonstrate the feasibility of meeting certain effluent limitations for storms less than the 10-year, 24-hour precipitation event. Analysis of the data indicate that for most precipitation events settleable solids of 0.5 ml/l and pH control between 6.0 and 9.0 can be achieved for ponds that are properly designed, constructed and maintained. Settleable solids monitoring is preferable to TSS monitoring as a method of regulating effluent sediment concentration during the exemption period since data obtained by this study indicate that TSS cannot always be effectively reduced.

SECTION VIII

COST, ENERGY AND NON-WATER QUALITY ISSUES

INTRODUCTION

The principal purpose of this chapter is to present results of a cost analysis for treatment technologies within each subcategory. Energy requirements and nonwater quality impacts such as solid waste generation and air pollution are also discussed for each treatment system. To conduct this analysis, a model plant approach was utilized. The first step in this procedure is to estimate average and maximum flow volumes and other design parameters. This was accomplished by review of pertinent literature and site visits to operating coal mines. From this information, capital and operating cost curves are prepared to reflect each component of the treatment system. These component costs are then assembled into overall costs for an entire treatment system or level. Energy usage for each technology is also computed.

The costs presented in this section are in 1979 dollars. A detailed breakdown of this section's summarized costs is presented in a cost manual developed as a part of this project (1), which is included as a supplement to this document. Additional assumptions and backup cost data are found in Appendix A and in reference (2).

The final step in the cost analysis was to verify the accuracy of model plant costs with actual costs at an active coal mine. This was achieved by first visiting various mines and collecting design and cost information and then computing system costs for that mine. The results, which are presented in Appendix A, were then compared with the model plant costs, using the actual flow at that mine.

Treatment methods such as reverse osmosis, electrodialysis, carbon adsorption, ion exchange, sulfide precipitation, and ozonation were initially considered as possible treatment processes for attaining BAT or NSPS compliance. These treatment systems are not included in this section because these systems are not feasible for reasons previously discussed. Table VIII-1 summarizes capital and operating costs for these systems based on a flow of 1.0 mgd.

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Table VIII-1

CAPITAL AND OPERATING COSTS OF ALTERNATE TREATMENT TECHNOLOGIES NOT RECOMMENDED FOR BAT

	Pollutants Treated	Capital Cost ($1,000's)	Operating Cost ($/1,000 gal)	Source
Carbon Adsorption	Organics and heavy metals	2,000	1.37 - 1.64	(1)
Ion Exchange	Dissolved solids and heavy metals	500 to 1,000	1.00 - 1.90	(6)
Reverse Osmosis	Dissolved solids and heavy metals	500 to 1,000	0.95 - 1.90	(6)
Electrodialysis	Dissolved solids and heavy metals	500	0.80 - 1.00	(6)
Ozonation	Cyanide Reduction	240	0.20 - 0.25	(1), (7)
Sulfide Precipitation	Heavy metals	No applicable data available	No applicable data available	

Basis: 1.0 mgd facility; 1979 dollars.

MINE DRAINAGE

Existing Sources

Treatment Levels

Four treatment systems (designated levels 1, 2, 3, and 4) were identified as the basis for the cost analysis. These systems incorporate the technically feasible technologies discussed in Section VII, as outlined below.

Level One. This system is typical of a BPT treatment configuration. As shown schematically in Figure VIII-1, this scheme consists of optional raw water holding for equalization, neutralization if required for acid drainage, optional aeration, settling, and optional sludge dewatering. Some type of pH monitoring and control is required.

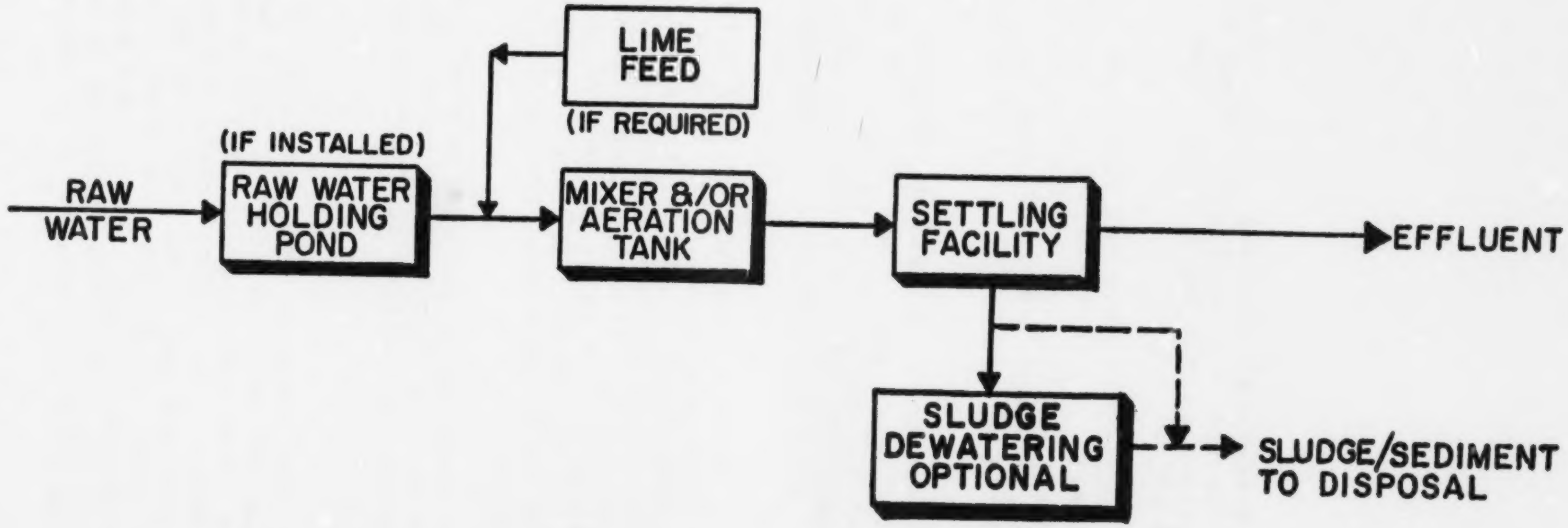
Level Two. This level consists of installing "add-on" equipment to the present BPT facilities to permit the addition of a flocculant aid. The flocculant aid is normally an organic polyelectrolyte added to promote agglomeration and subsequent settling of finer suspended solids. This level is depicted schematically in Figure VIII-2.

Level Three. This level, shown schematically in Figure VIII-3, consists of mixers and flocculator-clarifiers in lieu of sedimentation basins, and also additional chemical feed, mixing and aeration facilities. More sophisticated chemical and pH monitoring and control facilities are also included. This level of treatment would be applicable to a major upgrade of existing BPT facilities or where a mine was meeting BPT requirements without treatment facilities and would chose this treatment system to comply with BAT limitations.

Level Four. This level consists of the addition of granular media filtration to one or more of the first three levels of treatment. This technology is depicted in Figure VIII-4.

Capital Costs

Capital cost estimates were prepared for each level of treatment, in most cases for ranges between 0.02 and 9 million gallons per day (mgd). These flows cover the range of more than 99 percent of active discharging mines. The capital costs for each level of treatment include the purchase and installation of all necessary equipment but, in most cases, do not include land, power lines, access roads or sludge disposal costs. These costs are presented separately. Level 1 has not been costed since it is assumed to be installed to meet the BPT requirements. A 25 percent factor


LIME
FEED
(IF REQUIRED)
(IF INSTALLED)
RAW
WATER
RAW WATER
HOLDING
POND
MIXER &/OR
AERATION
TANK
SETTLING
FACILITY
EFFLUENT
SLUDGE
DEWATERING
OPTIONAL
SLUDGE/SEDIMENT
TO DISPOSAL

NOTE:

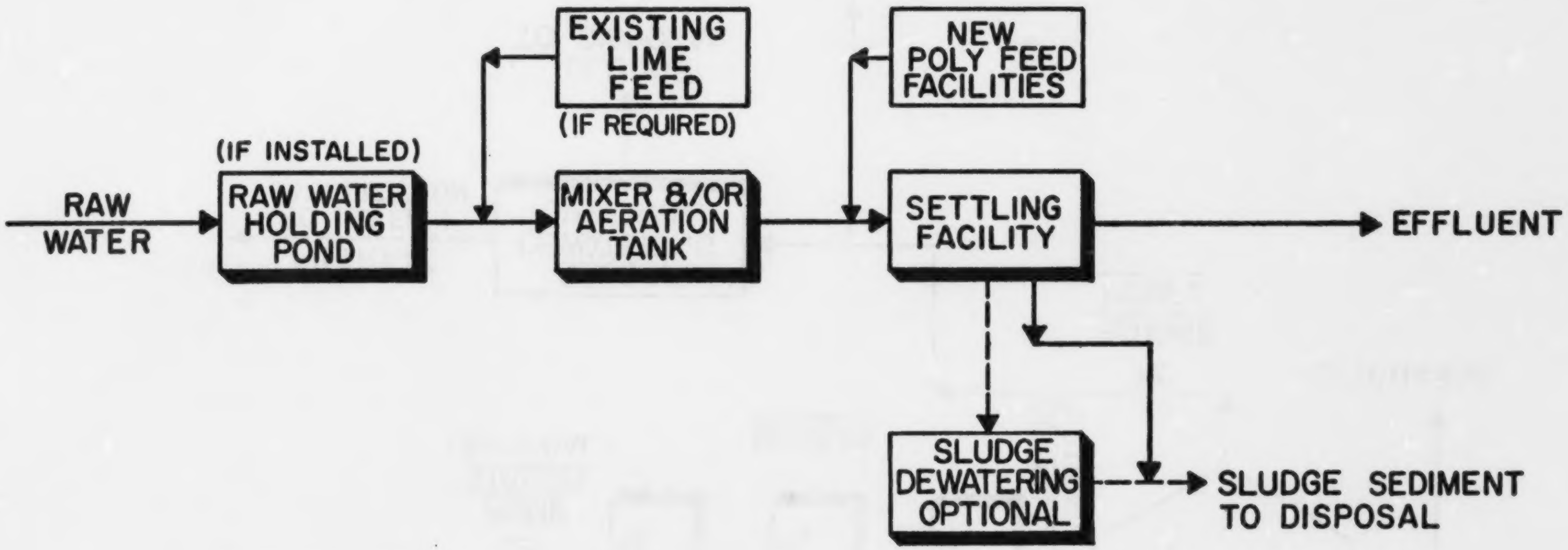
AERATION STEP NOT USED FOR WATERS CONTAINING NON-FERROUS IRON.

Figure VIII-1

SCHEMATIC OF LEVEL 1 (BPT) FACILITIES

Figure VIII-3

SCHEMATIC OF LEVEL 3 MINE WATER TREATMENT SYSTEM

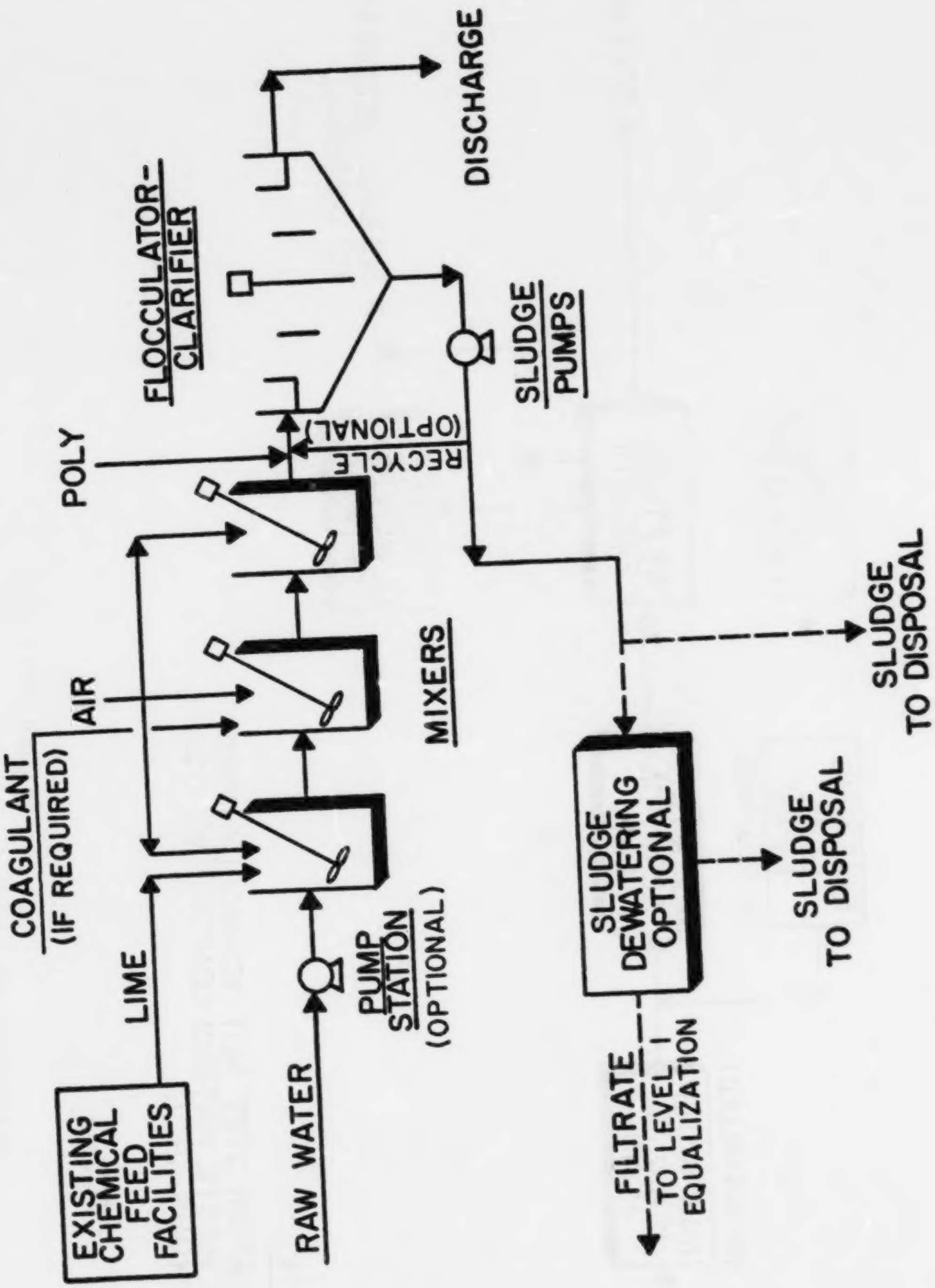

EXISTING
LIME
FEED
(IF REQUIRED)
NEW
POLY FEED
FACILITIES
(IF INSTALLED)
RAW
WATER
RAW WATER
HOLDING
POND
MIXER &/OR
AERATION
TANK
SETTLING
FACILITY
EFFLUENT
SLUDGE
DEWATERING
OPTIONAL
SLUDGE SEDIMENT
TO DISPOSAL

NOTE:

AERATION STEP NOT NORMALLY USED FOR WASTE WATERS CONTAINING NON-FERROUS IRON.

Figure VIII-2

SCHEMATIC OF LEVEL 2 SYSTEM TO TREAT ACID DRAINAGE


EXISTING CHEMICAL FEED FACILITIES
LIME
COAGULANT
(IF REQUIRED)
AIR
RAW WATER
PUMP STATION
(OPTIONAL)
MIXERS
POLY
RECYCLE
(OPTIONAL)
FLOCCULATOR-CLARIFIER
SLUDGE PUMPS
DISCHARGE
SLUDGE DEWATERING OPTIONAL
SLUDGE TO DISPOSAL
SLUDGE TO DISPOSAL
FILTRATE
TO LEVEL I EQUALIZATION

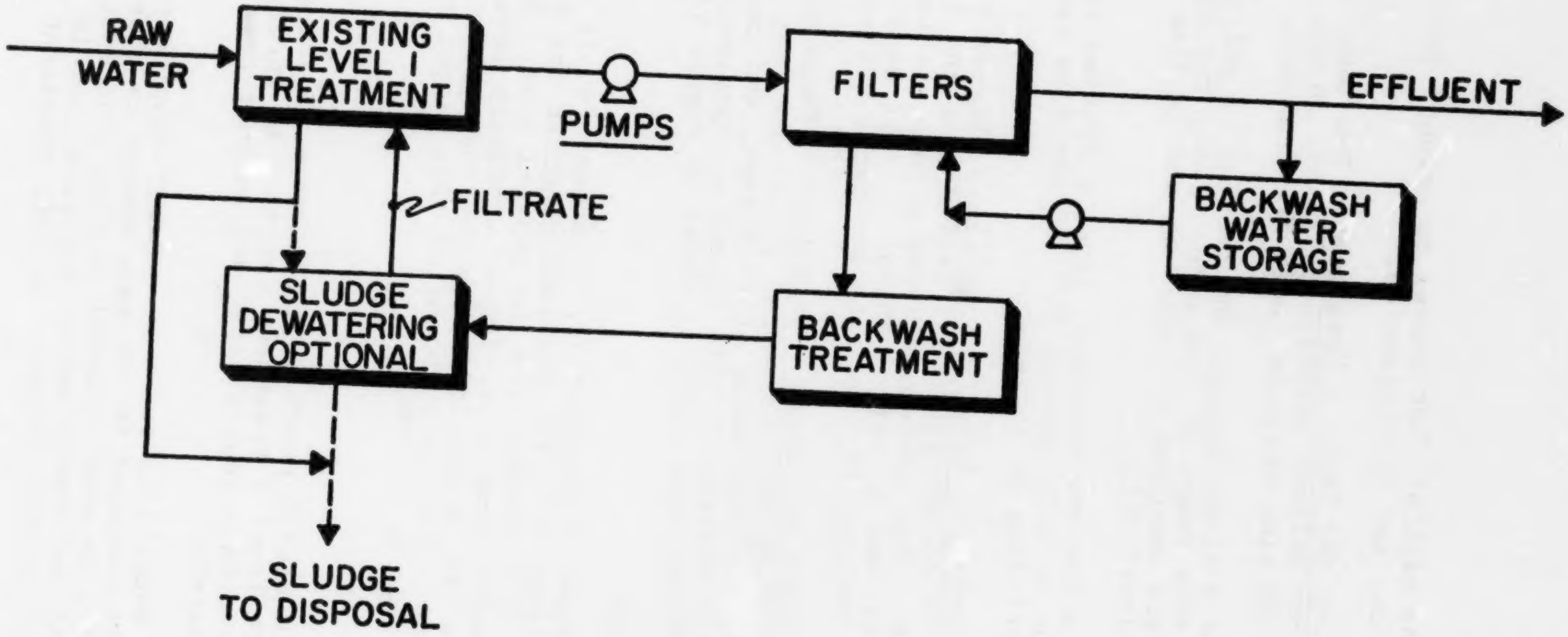

RAW WATER
EXISTING LEVEL I TREATMENT
PUMPS
FILTERS
EFFLUENT
FILTRATE
BACKWASH WATER STORAGE
SLUDGE DEWATERING OPTIONAL
BACKWASH TREATMENT
SLUDGE TO DISPOSAL

Figure VIII-4
SCHEMATIC OF LEVEL 4 - FILTRATION OF LEVEL 1 EFFLUENT ACID MINE WATER

is included in the capital cost curves to account for engineering, administration, and contingencies.

System Capital Cost for Level 2 Treatment. The level 2 treatment system provides for polymer addition as an aid in the removal of suspended solids in mine drainage (acid or alkaline).

Equipment for the mixing, storage and feeding of polymer can be operated over a wide range of flow rates. Only two different polymer systems are required to cover the entire flow range of 0.02 to 4.5 mgd level (1).

The capital costs for the treatment level 2 systems are $30,000 for flow rates up to 0.75 mgd and $40,000 for flow rates greater than 0.75 mgd including an enclosure.

System Capital Costs for Level 3 Treatment. Figure VIII-3 presented a schematic of the equipment included in the level 3 treatment system. This system includes a pump station, mixing tanks, clarifiers, and a control building. The capital costs are presented as a function of flow rate in Figure VIII-5.

System Capital Costs for Level 4 Treatment. The equipment and facilities comprising this treatment system are pump station, gravity filters, backwash water storage tank, and control building. A schematic diagram of this system was presented in Figure VIII-4. The capital cost curve is shown in Figure VIII-6.

Land Requirements

The land requirements computed for treatment levels 3 and 4 are presented in Figure VIII-7. The land required for level 2 should be minimal and is included with the capital cost. Once the land area that is needed from a particular treatment level is known, then this value can be multiplied by the cost per acre at the site in question. For the purposes of this report the cost per acre is assumed to be $4,000.

Annual Costs

Level 2. Table VIII-2 provides a breakdown of annual costs associated with level 2 treatment system. By incorporating the appropriate amortized capital cost and polymer cost, Figure VIII-8 was generated.

Level 3. The annualized costs and energy requirements for level 3 treatment are computed in the same manner as those for level 2. Polymer addition is also included in this treatment level and the annualized cost and energy curves are presented in Figure VIII-9 with a two mg/l polymer dosage. In this treatment system, two

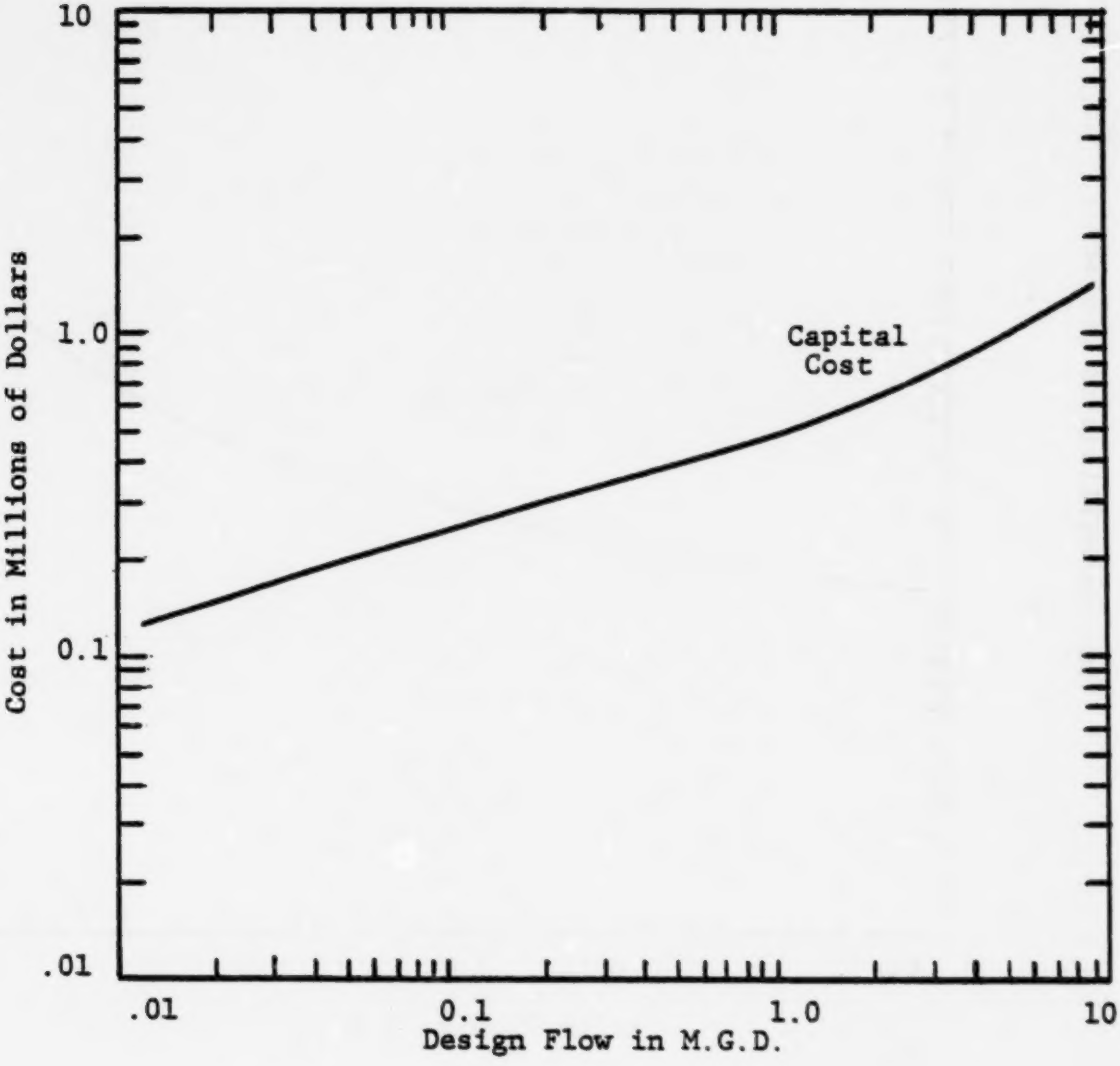


Figure VIII-5

LEVEL 3 TREATMENT OF MINE DRAINAGE - CAPITAL COST VERSUS FLOW RATE

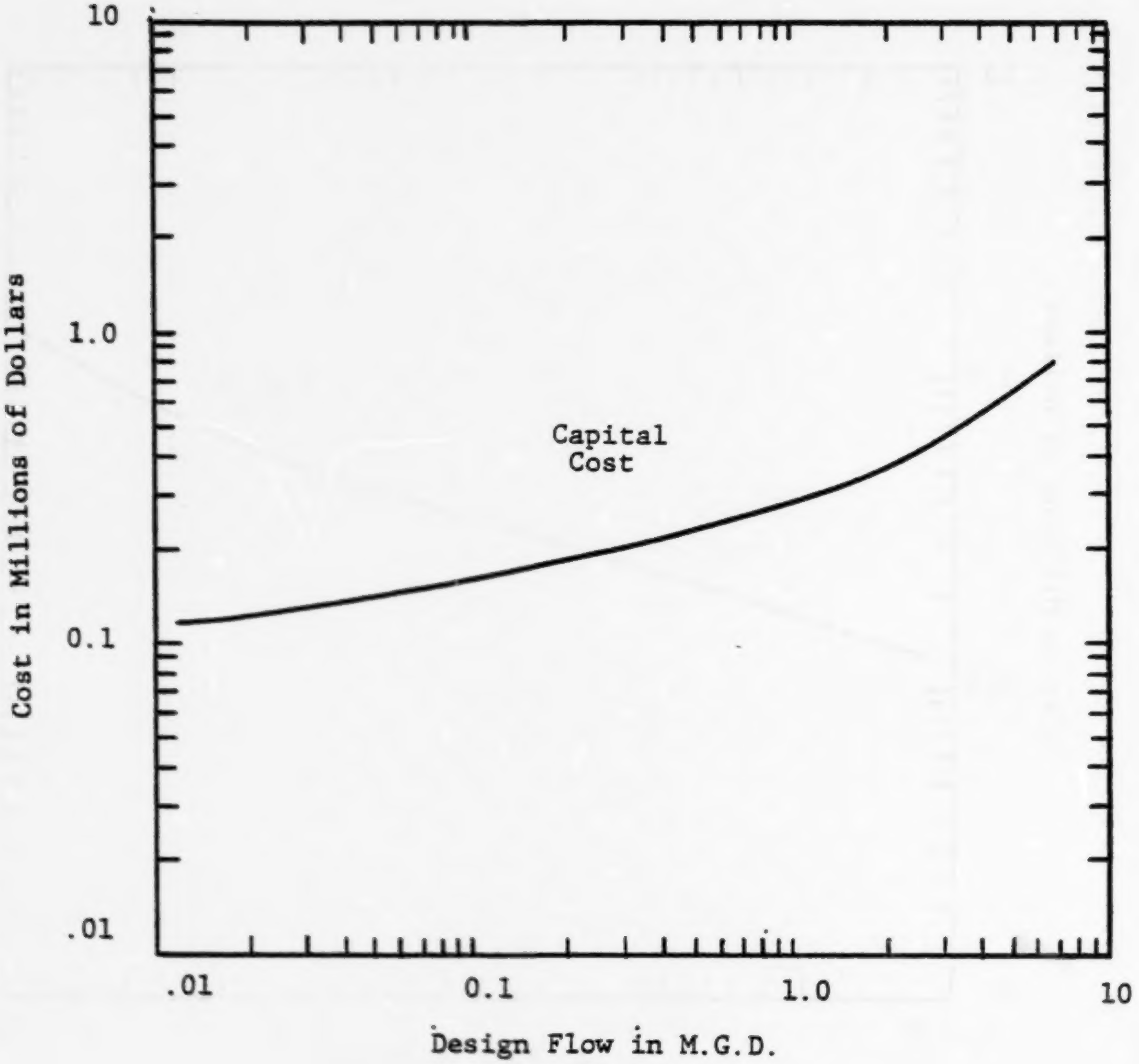


Figure VIII-6

LEVEL 4 TREATMENT OF ACID MINE DRAINAGE BY FILTRATION CAPITAL COST VERSUS FLOWRATE

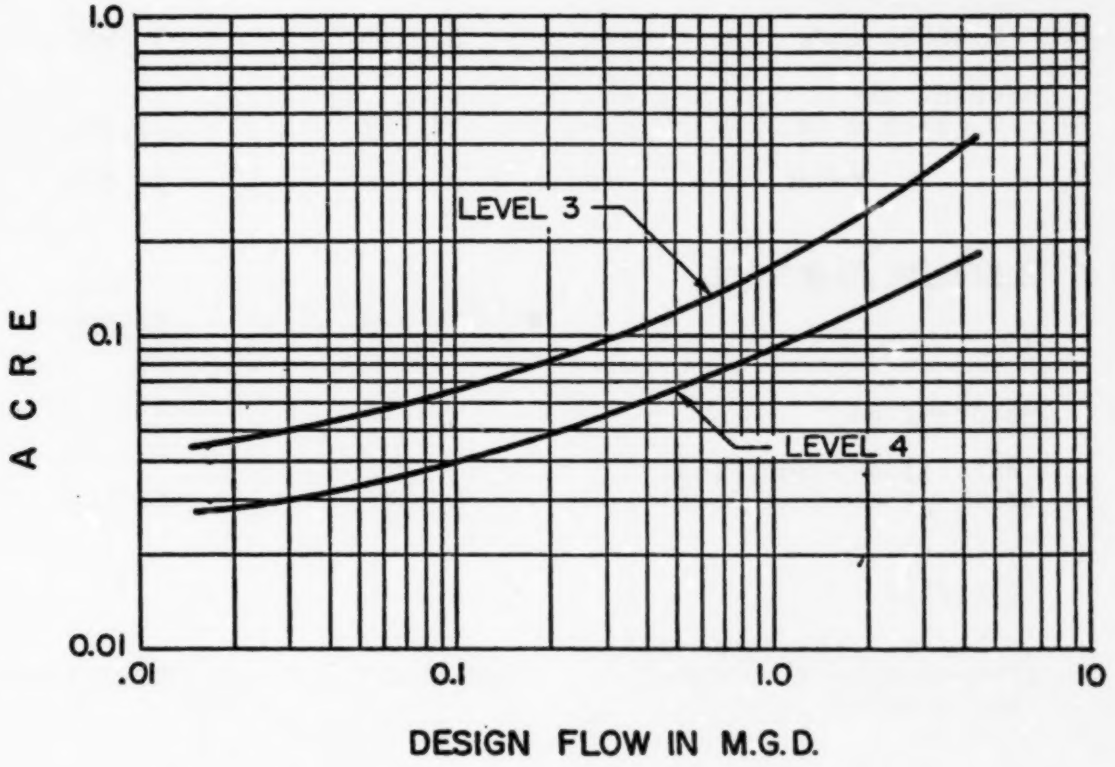


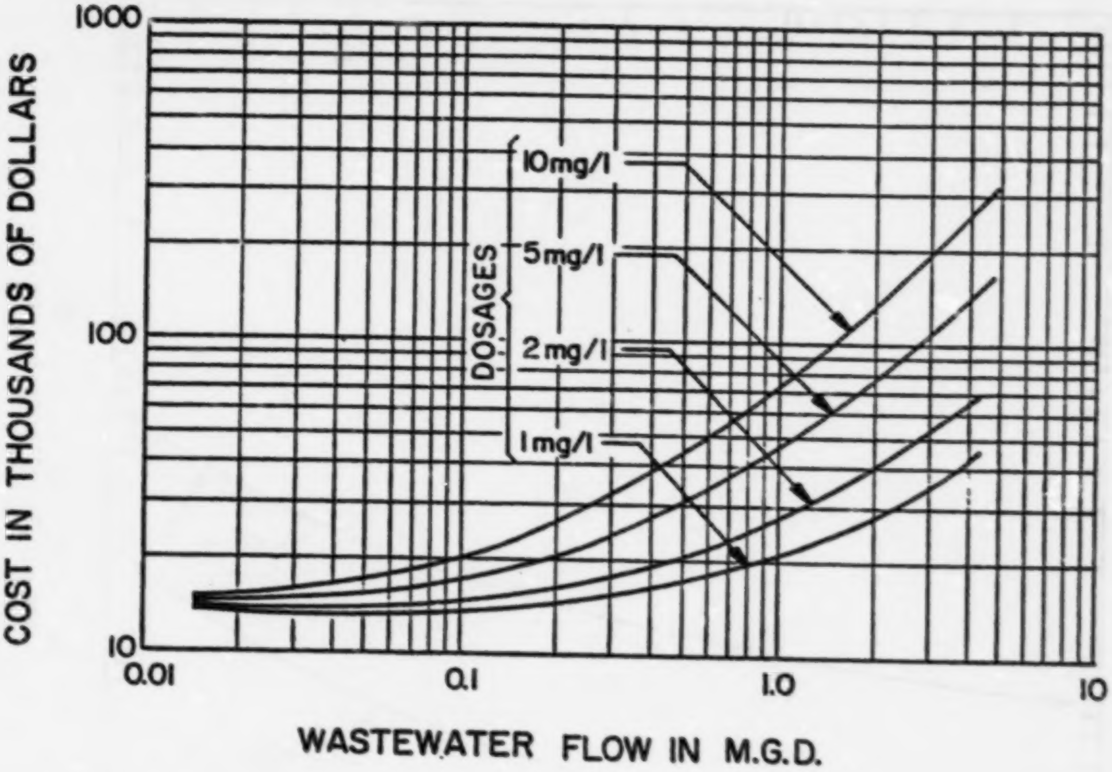
Figure VIII-7

MINE WATER TREATMENT SYSTEM
DESIGN FLOW VERSUS LAND AREA
REQUIREMENTS

Table VIII-2

BREAKDOWN OF ANNUALIZED COST FOR LEVEL 2 TREATMENT SYSTEM

	0.015-1.0 mgd	1.0-4.5 mgd
1. **Capital Recovery**		
Construction: 0.10608 x Cc	$ 500	$ 900
Mechanical: 0.16725 x Cc	3,200	5,100
TOTAL	$3,700	$6,000
2. **Operating Personnel**	$9,000	$9,000
3. **Maintenance**		
(Materials & Supplies) (@ 3% of Capital Cost)	$ 900	$1,200
4. **Chemicals**		
(@ $2/lb & 365 days/year) (function of flow rate and dosage)	$91-46,000	$6,000-274,000
5. **Energy**		
(@ $0.03/kW-hr, 24 hr/d, 365 d/yr)	$ 400	$ 700



NOTE:

CAPITAL COST IS:
FOR FLOW ≤750,000 gpd — $ 30,000
≥750,000 gpd — $ 40,000

Figure VIII-8
WASTEWATER TREATMENT FLOCCULANT (POLYMER) ADDITION
ANNUAL COST CURVES AND CAPITAL COST DATA

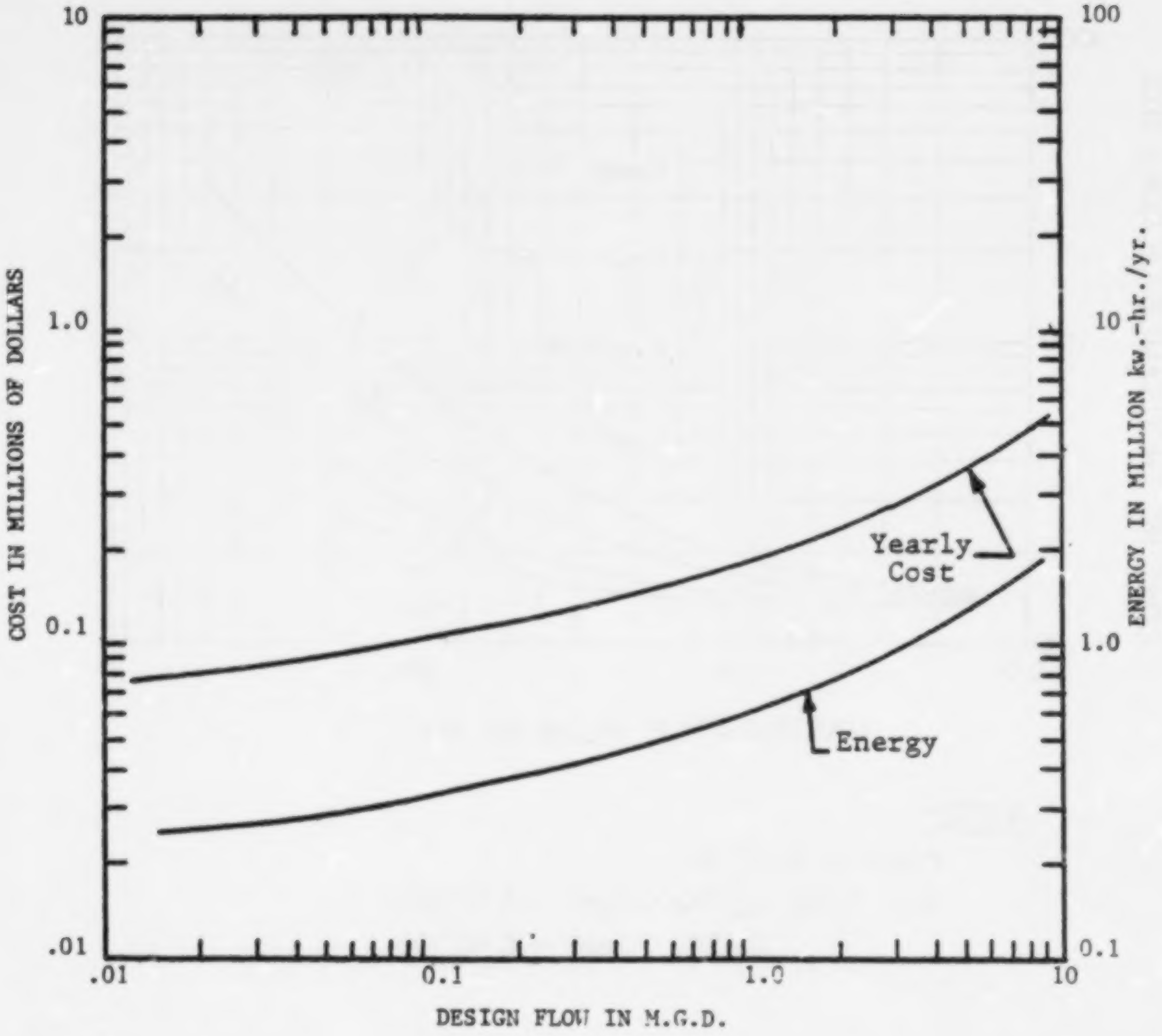


Figure VIII-9

TREATMENT LEVEL 3 ANNUALIZED COSTS AND ENERGY REQUIREMENTS VERSUS MINE DRAINAGE FLOWRATES operators per shift are assumed for flow rates up to 0.75 mgd; above 0.75 mgd, three shift operators are required.

Level 4. Annualized costs and energy requirements for level 4 treatment were estimated by the same process used for level 2 and are presented in Figure VIII-10. Only one operator per shift is required for this system.

New Sources

Four treatment levels were also established for new sources in the mine drainage subcategory. These levels correspond closely to the treatment levels under existing sources, with only minor modifications in levels 3 and 4. As shown in Figure VIII-11, level 3 for new sources would include recycle of filtrate from sludge dewatering equipment to the head of the treatment plant. Level 4 for new sources is modified to include levels 1, 2, or 3, as shown in Figure VIII-12.

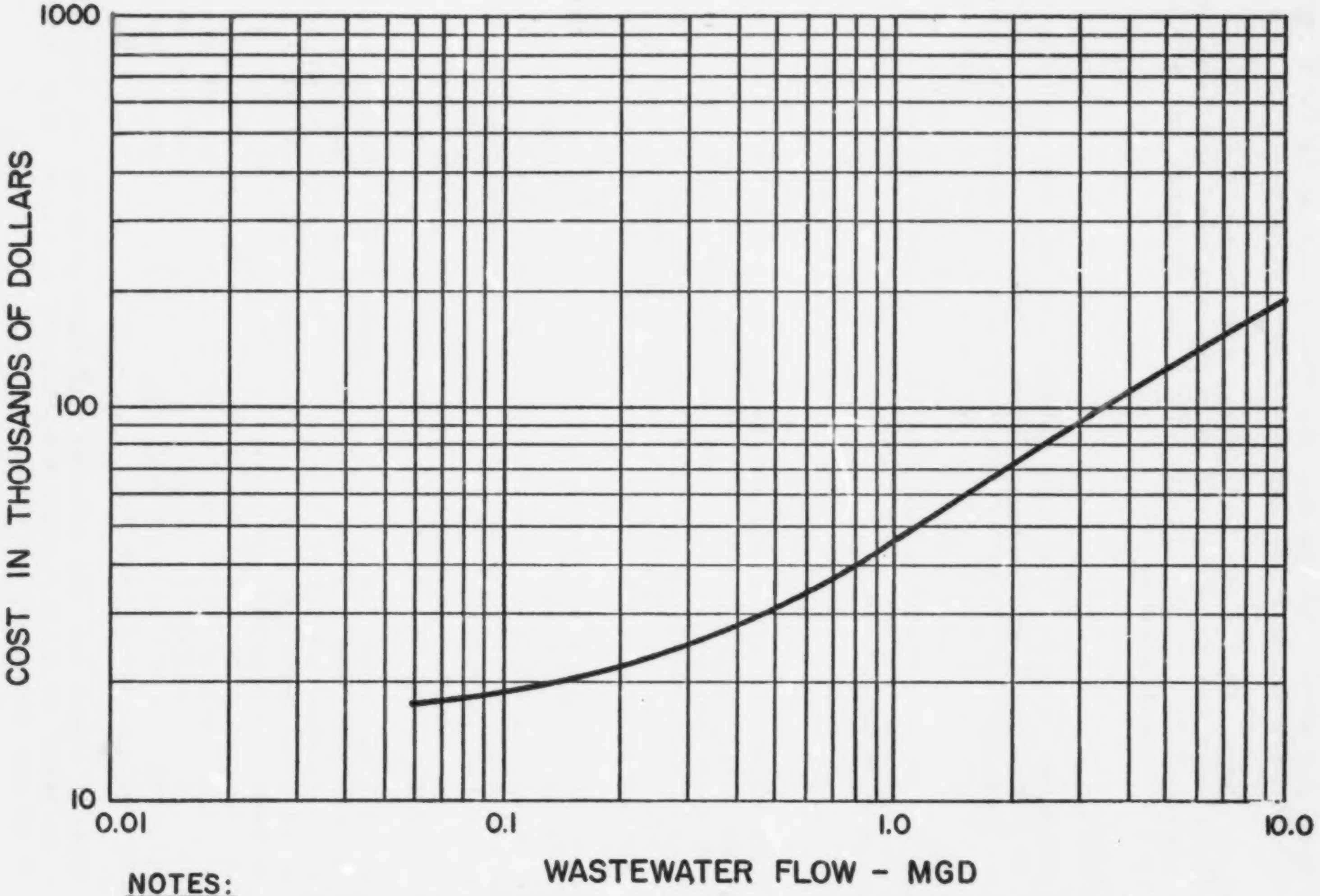
Capital Costs

The capital cost assumptions for new sources are identical to those made for existing sources, with one major exception. New sources by definition do not have any existing treatment installed, while existing sources were assumed to have BPT or equivalent in place. Therefore, new source capital (and annual) cost estimates must include the cost of BPT facilities as well.

System Capital Costs for Level 1 Treatment. The level 1 treatment system provides for the construction of a sedimentation basin or clarifier to remove suspended matter from mine drainage (acid and alkaline). The capital costs for sedimentation ponds are presented in Figure VIII-13. If lime feed equipment is required and the dosage known, Figure VIII-14 can be used to determine the cost of installed equipment.

System Capital Costs for Level 2 Treatment. The level 2 treatment system provides for the construction of a sedimentation basin for polymer addition as an aid in the removal of suspended matter in mine drainage (acid or alkaline). The capital costs for sedimentation ponds are presented in Figure VIII-13. Since the sedimentation pond sizing is based on the area storm runoff while the polymer addition equipment is based on the dry weather flow, it is infeasible to prepare cost curves of combined sedimentation basins and polymer addition equipment costs. Therefore separate curves are presented.

The capital costs for the polymer addition systems are $30,000 for flow rates up to 0.75 mgd and $40,000 for flow rates greater than 0.75 mgd including an enclosure.



NOTES:
(1) WASTEWATER SAMPLE ANALYSIS NOT INCLUDED. (2) LOADING RATE = 10 GPM/FT^2

Figure VIII-10

LEVEL 4 WASTEWATER TREATMENT ANNUAL COST CURVE

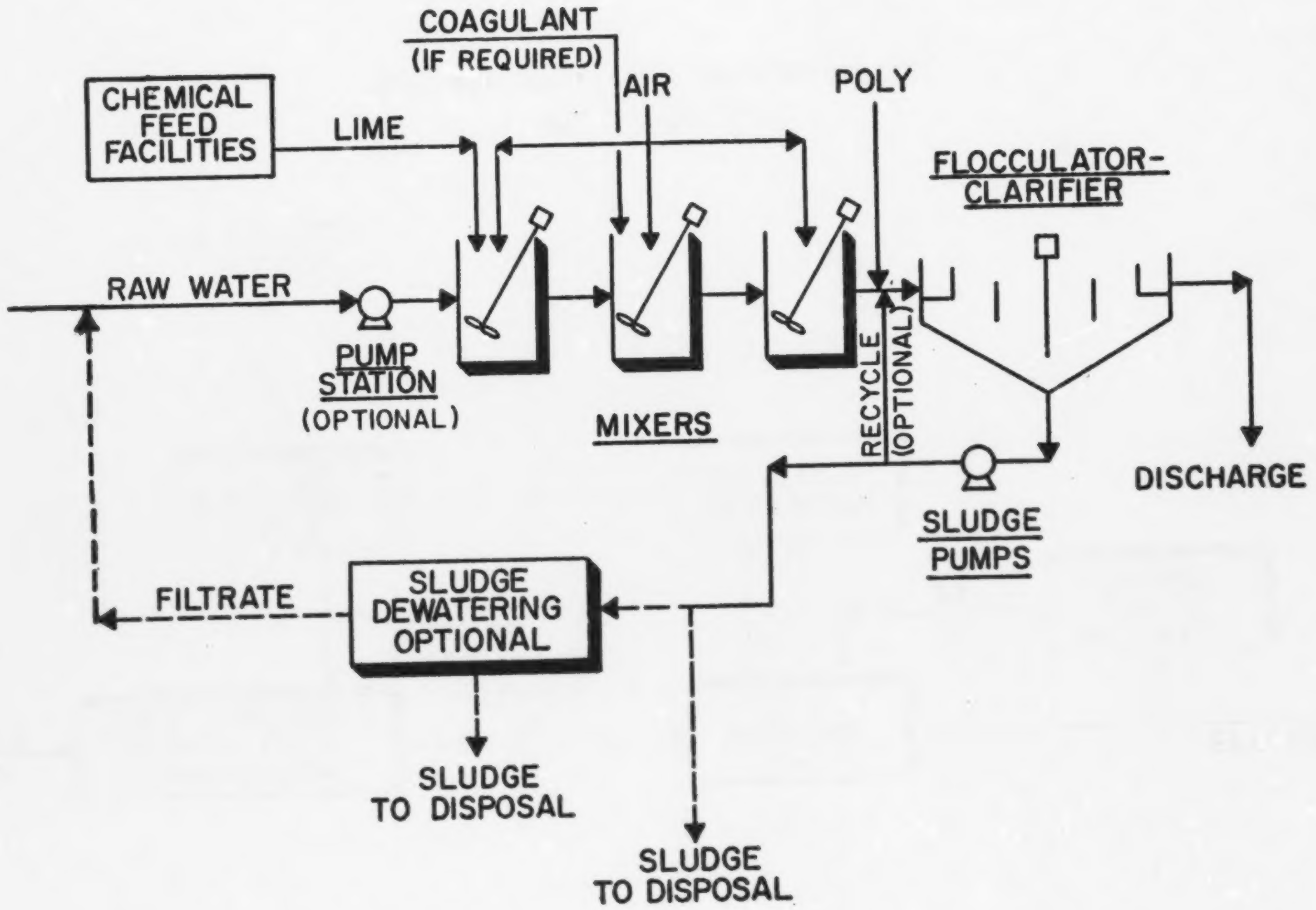

COAGULANT
(IF REQUIRED)
CHEMICAL FEED FACILITIES
LIME
AIR
POLY
FLOCCULATOR-CLARIFIER
RAW WATER
PUMP STATION
(OPTIONAL)
MIXERS
RECYCLE
(OPTIONAL)
DISCHARGE
SLUDGE PUMPS
FILTRATE
SLUDGE DEWATERING OPTIONAL
SLUDGE TO DISPOSAL
SLUDGE TO DISPOSAL

Figure VIII-11
SCHEMATIC OF LEVEL 3 NSPS FACILITIES

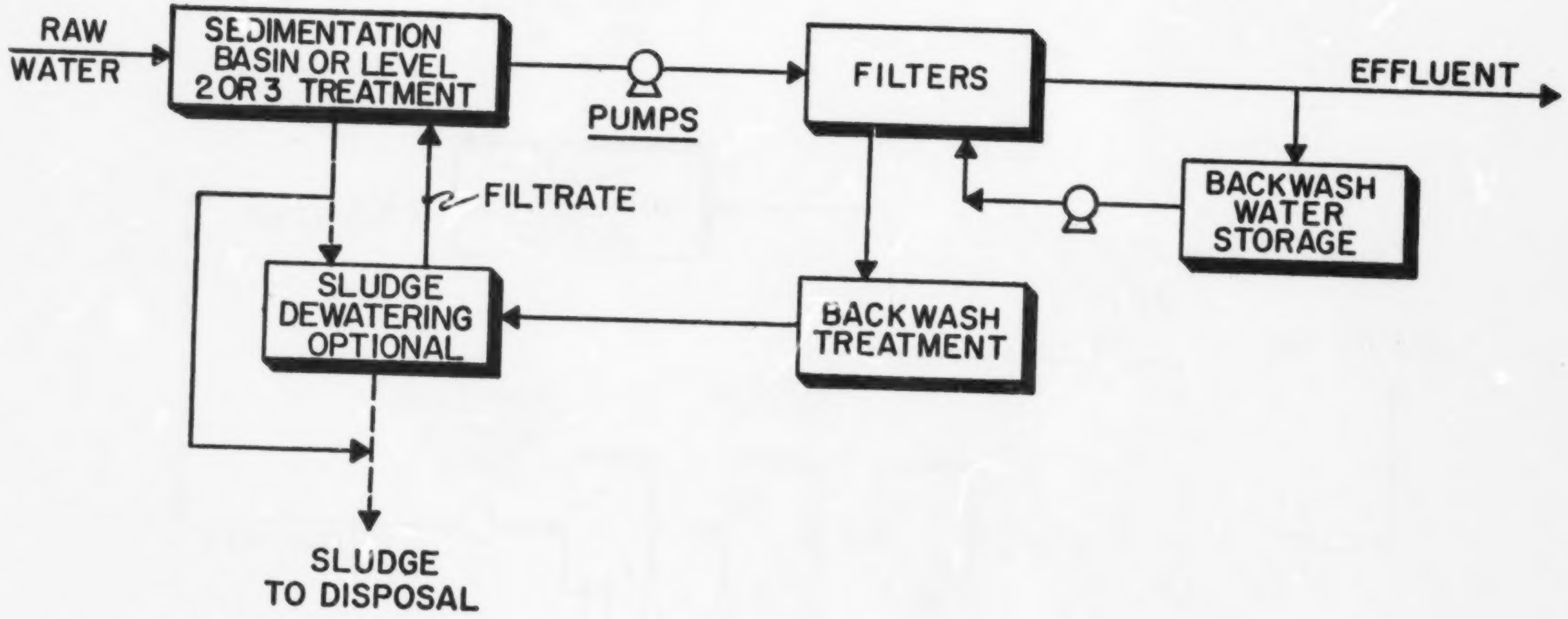

RAW WATER
SEDIMENTATION BASIN OR LEVEL 2 OR 3 TREATMENT
PUMPS
FILTERS
EFFLUENT
FILTRATE
BACKWASH WATER STORAGE
SLUDGE DEWATERING OPTIONAL
BACKWASH TREATMENT
SLUDGE TO DISPOSAL

Figure VIII-12
SCHEMATIC OF LEVEL 4 NSPS FACILITIES

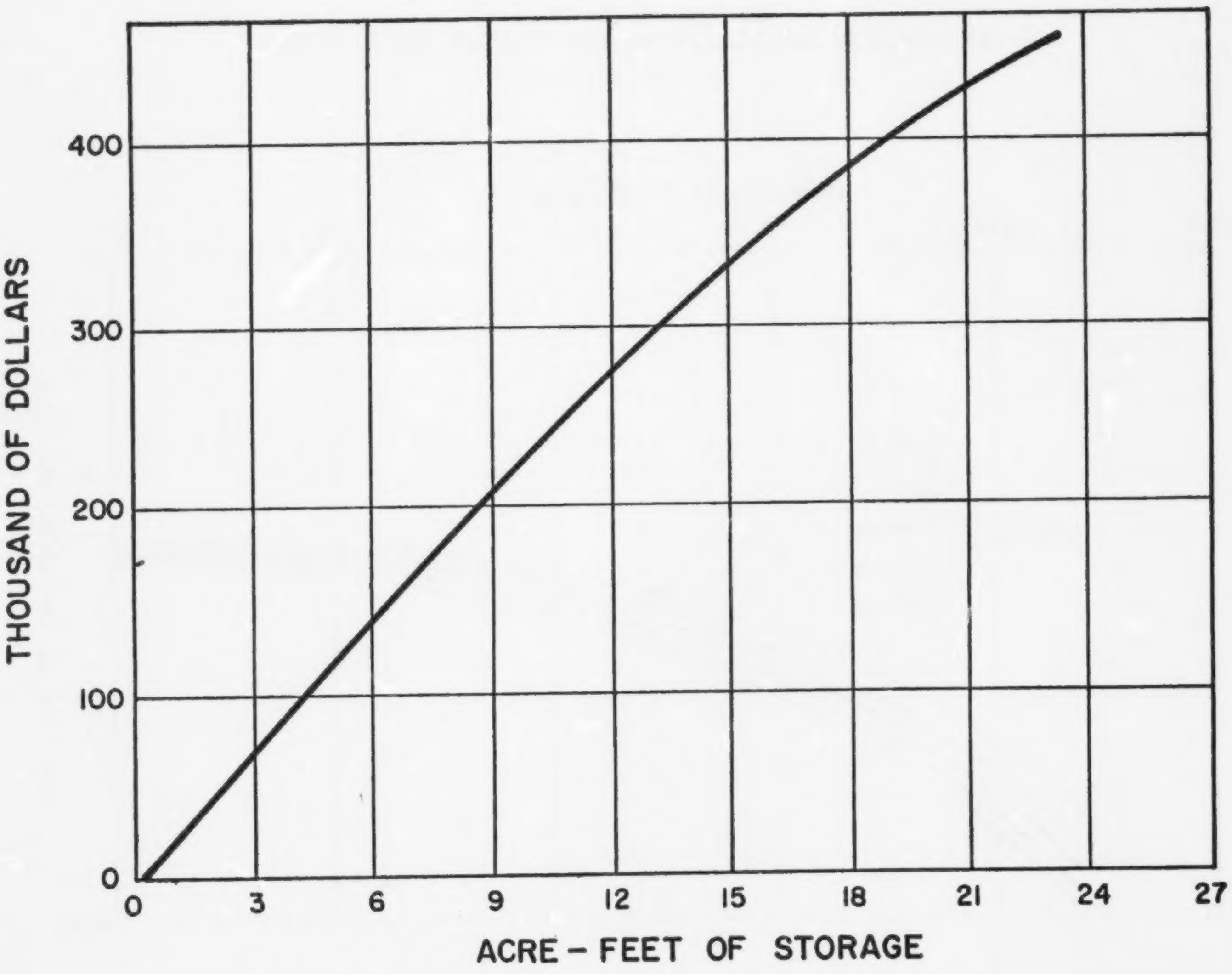


Figure VIII-13

WASTEWATER TREATMENT SEDIMENTATION POND STORAGE
VERSUS CAPITAL COST CURVE

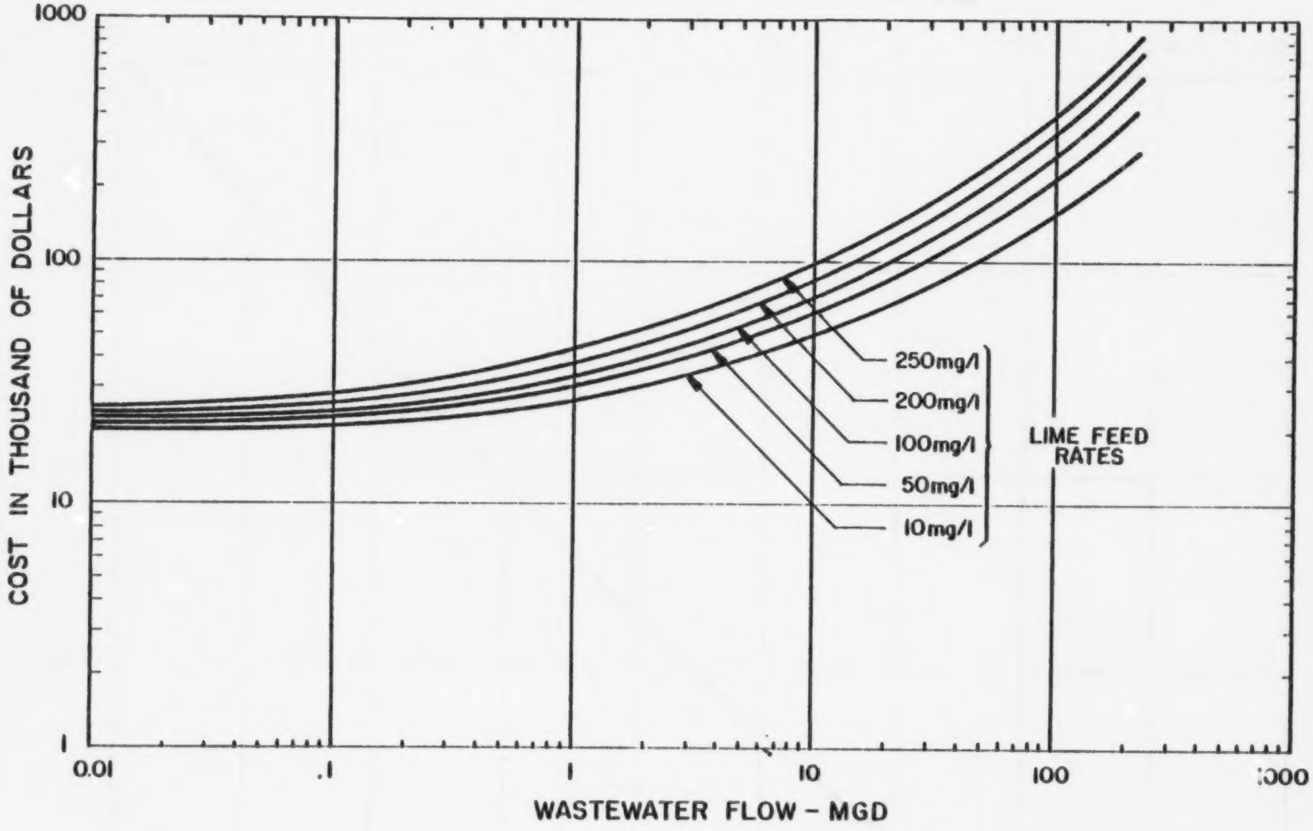


Figure VIII-14

LEVEL 1 MINE WASTEWATER TREATMENT pH ADJUSTMENT
CAPITAL COST CURVES

System Capital Costs for Level 3 Treatment. This system includes a pump station, mixing tanks, clarifiers, and a control building. The capital costs were presented as a function of flow rate in Figure VIII-5.

System Capital Costs for Level 4 Treatment. The equipment and facilities comprising this treatment system are pump station, gravity filters, backwash water storage tank, and control building. A schematic diagram of this system was presented in Figure VIII-4. The capital cost curve was shown in Figure VIII-6. This level of treatment must be applied after either a sedimentation basin alone, or after level 3 treatment. If the total cost for this system is required the costs from Figure VIII-6 should be combined with costs for the appropriate sedimentation basin or the level 3 costs.

Land Requirements

The land requirements for levels 3 and 4 were presented in Figure VIII-7. An insignificant amount of land is required for level 2.

Annual Costs

Level 1. The annual costs for level 1 are composed of sedimentation basin annual costs from Figure VIII-15, lime feeding for pH adjustment from Figure VIII-16 if required and sludge dewatering from Figure VIII-17 if this is installed.

Level 2. The annual costs for level 2, polymer addition, were presented in Figure VIII-8.

Level 3. The annual costs for level 3 were presented in Figure VIII-9.

Level 4. The annual costs for level 4 were presented in Figure VIII-10.

PREPARATION PLANTS AND ASSOCIATED AREAS

Existing Sources

Water discharged from coal preparation plants and their immediate areas originates from two sources: (1) preparation plant process wastewater (PP) and (2) wastewater generated in the vicinity of the plant facilities, from coal storage areas, and from refuse disposal areas (Associated Area Runoff (AA)).

These discharges are disposed of in various methods depending on the specific site under consideration. For instance, the flows could be segregated or commingled. The preparation plant water circuit could be once-through or with partial or total recycle of

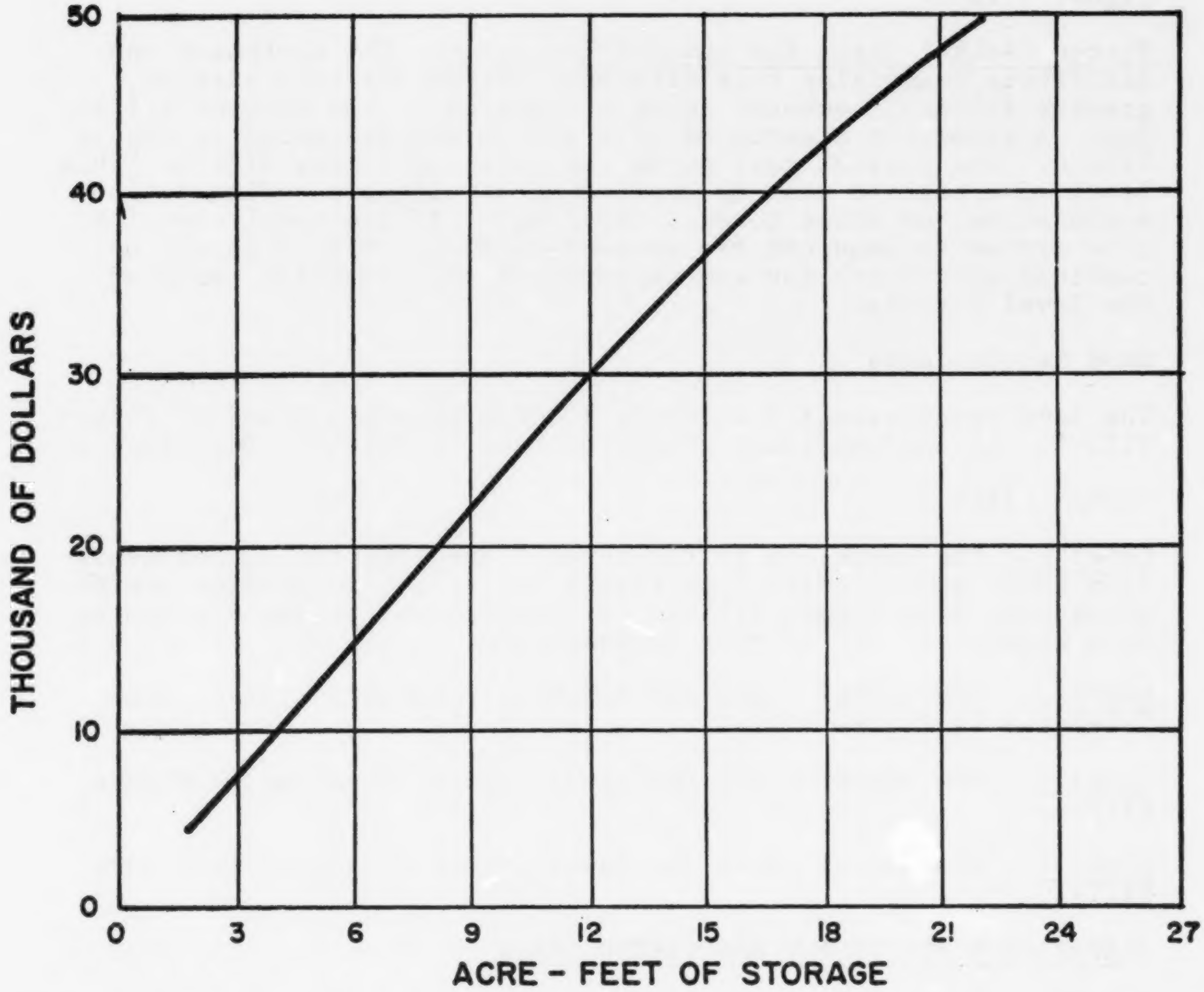


Figure VIII-15

WASTEWATER TREATMENT SEDIMENTATION POND
ANNUAL COST CURVE

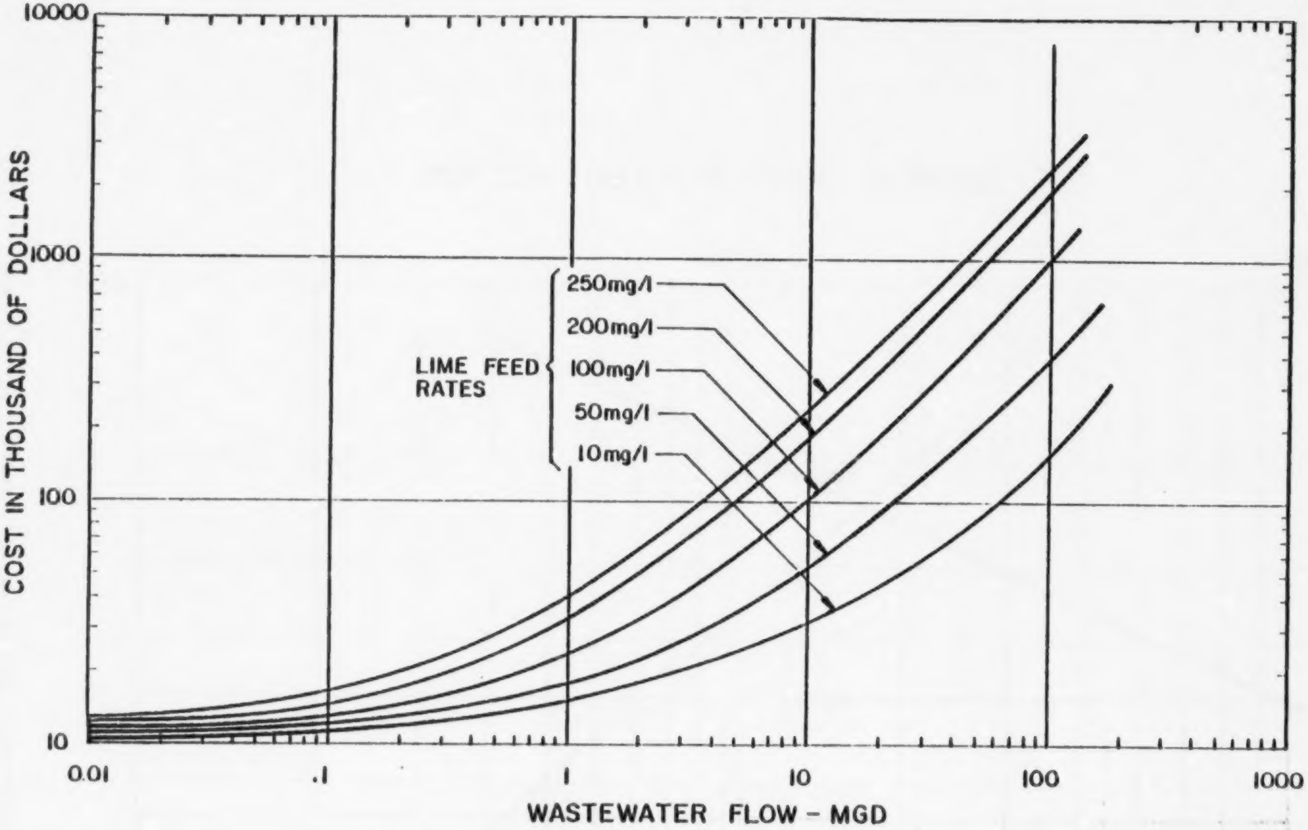


Figure VIII-16

LEVEL 1 MINE WASTEWATER TREATMENT pH ADJUSTMENT
ANNUAL COST CURVES

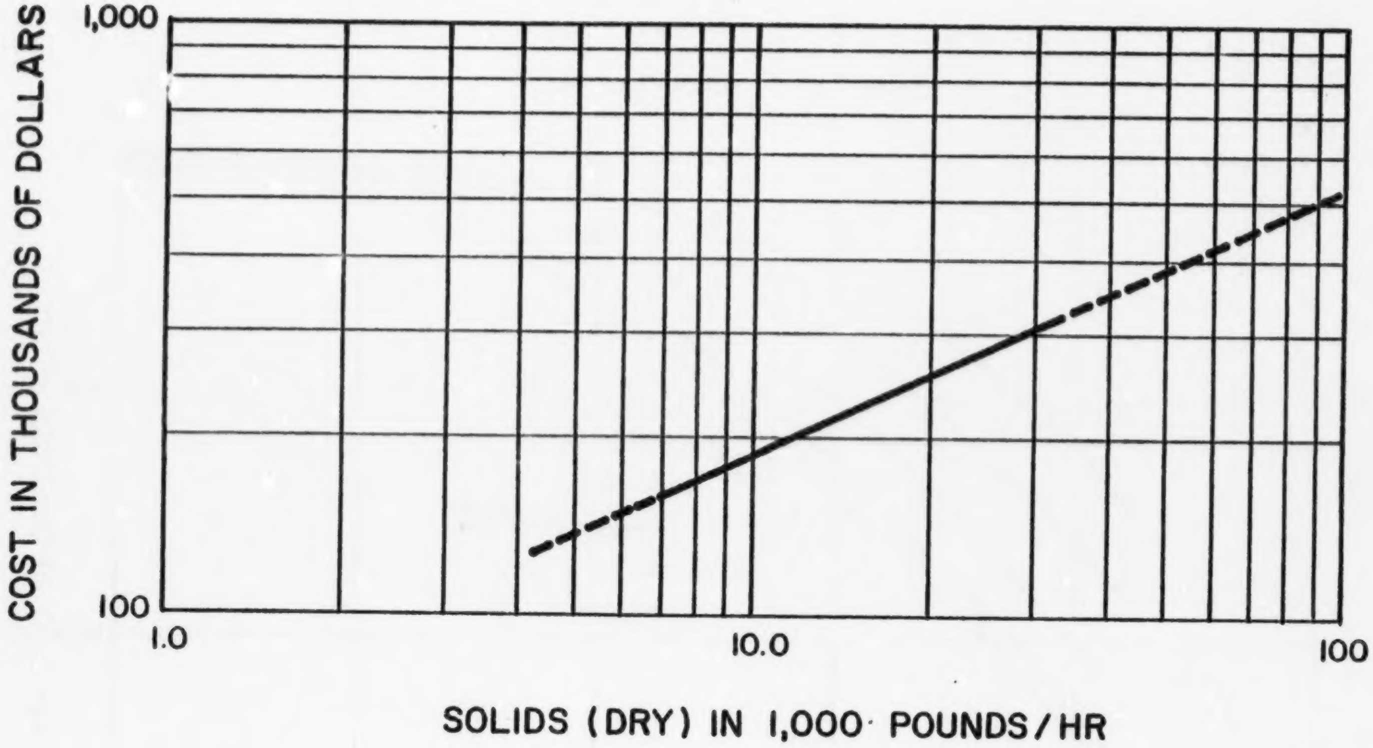


Figure VIII-17
WASTEWATER TREATMENT VACUUM FILTRATION
SLUDGE DEWATERING FACILITIES CAPITAL CURVE

process wastewaters. Various systems have been costed in an attempt to cover each of the water handling options (3). These options and systems are discussed below.

Zero Discharge of Preparation Plant Water Circuit

Three systems were identified for existing sources to achieve total recycle of preparation plant process wastewater (also termed "zero discharge").

System 1. This system, shown in Figure VIII-18, assumes that a pond system is installed, the preparation plant presently has from 0 to 100 percent recycle, and the associated area storm runoff enters the preparation plant water circuit. In this case, the existing sedimentation basin would require dikes to divert the associated area runoff to a new sedimentation pond designed to contain the volume of runoff from a 10-year, 24-hour storm and also diversion of the undisturbed area runoff around the associated area.

System 2. This system assumes that preparation plant wastewater and associated area runoff are segregated for treatment. A clarifier is installed to treat the preparation plant wastewater. Recycle from the clarifier overflow to the preparation plant can vary from 0 to 100 percent. A sedimentation pond is assumed to be in place which receives only associated area runoff and possibly some undisturbed area runoff. Figure VIII-19 is a schematic of this system.

System 3. This system, shown in Figure VIII-20, assumes a clarifier is installed to treat preparation plant wastewater. The clarifier discharge and associated area runoff presently are combined and routed to an existing pond for treatment. Recycle from the pond can vary from 0 to 100 percent. Modifications would include the elimination of the pond from the preparation plant water circuit by installing a new pump station to route 100 percent of the clarifier overflow to the preparation plant. The pond would, however, continue to provide treatment for the associated area runoff.

Allowable Discharge from the Preparation Plant Water Circuit

Since this configuration is currently the option selected by most plants, only one system was identified for costing purposes.

System 4. This scenario assumes an allowable discharge from the preparation plant water circuit. Preparation plant waters may or may not be recycled. Figure VIII-21 is a schematic of this system showing the preparation plant discharge treated first in

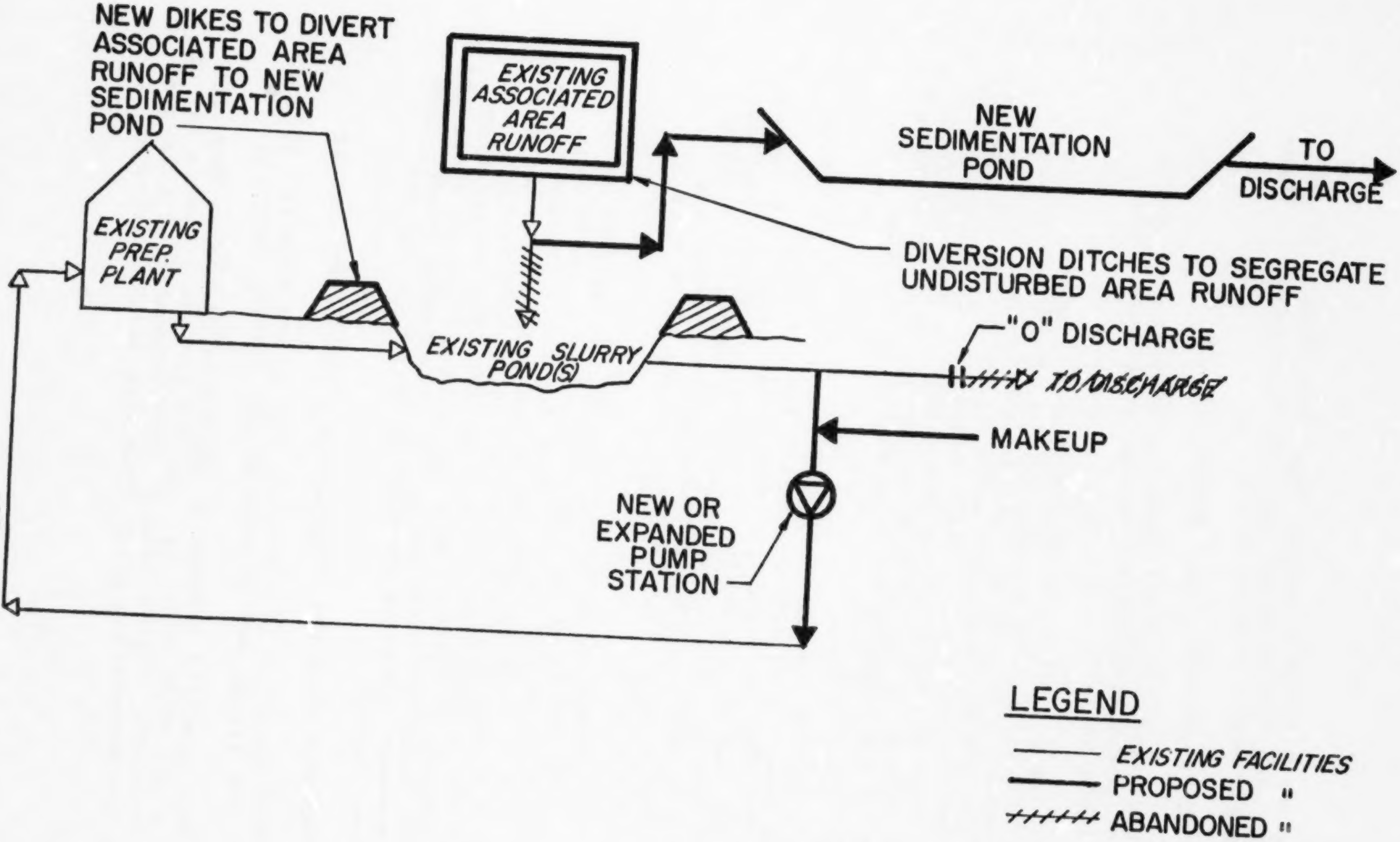

NEW DIKES TO DIVERT ASSOCIATED AREA RUNOFF TO NEW SEDIMENTATION POND
EXISTING ASSOCIATED AREA RUNOFF
NEW SEDIMENTATION POND
TO DISCHARGE
EXISTING PREP. PLANT
DIVERSION DITCHES TO SEGREGATE UNDISTURBED AREA RUNOFF
EXISTING SLURRY POND(S)
"O" DISCHARGE
TO DISCHARGE
MAKEUP
NEW OR EXPANDED PUMP STATION
LEGEND
EXISTING FACILITIES
PROPOSED "
ABANDONED "

Figure VIII-18
EXISTING PREPARATION PLANT - SYSTEM 1 WATER CIRCUITS - ZERO DISCHARGE

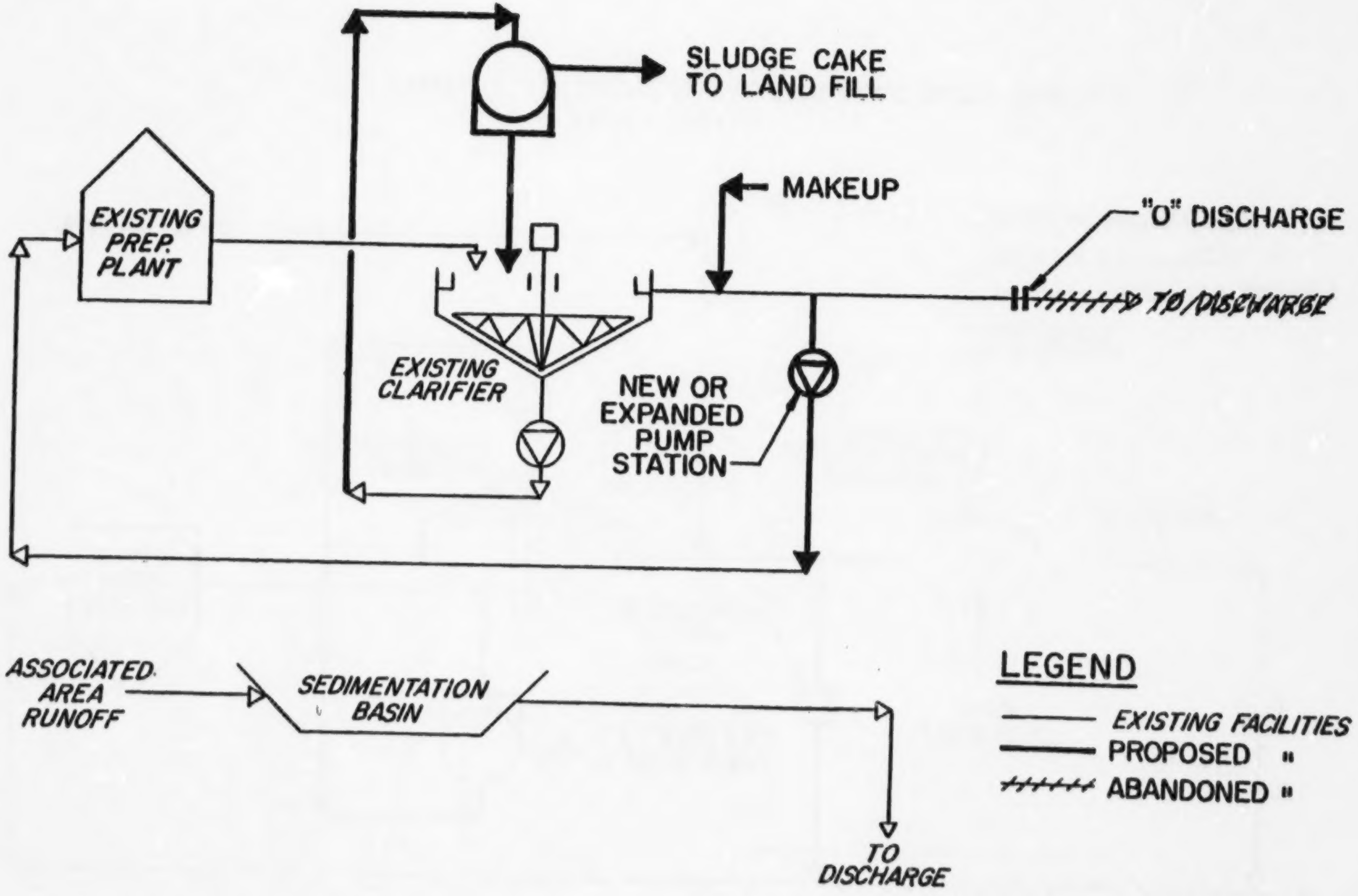

SLUDGE CAKE TO LAND FILL
EXISTING PREP. PLANT
MAKEUP
"O" DISCHARGE
TO DISCHARGE
EXISTING CLARIFIER
NEW OR EXPANDED PUMP STATION
ASSOCIATED AREA RUNOFF
SEDIMENTATION BASIN
TO DISCHARGE
LEGEND
EXISTING FACILITIES
PROPOSED "
ABANDONED "

Figure VIII-19

SYSTEM 2 - EXISTING PREPARATION PLANT WATER CIRCUITS

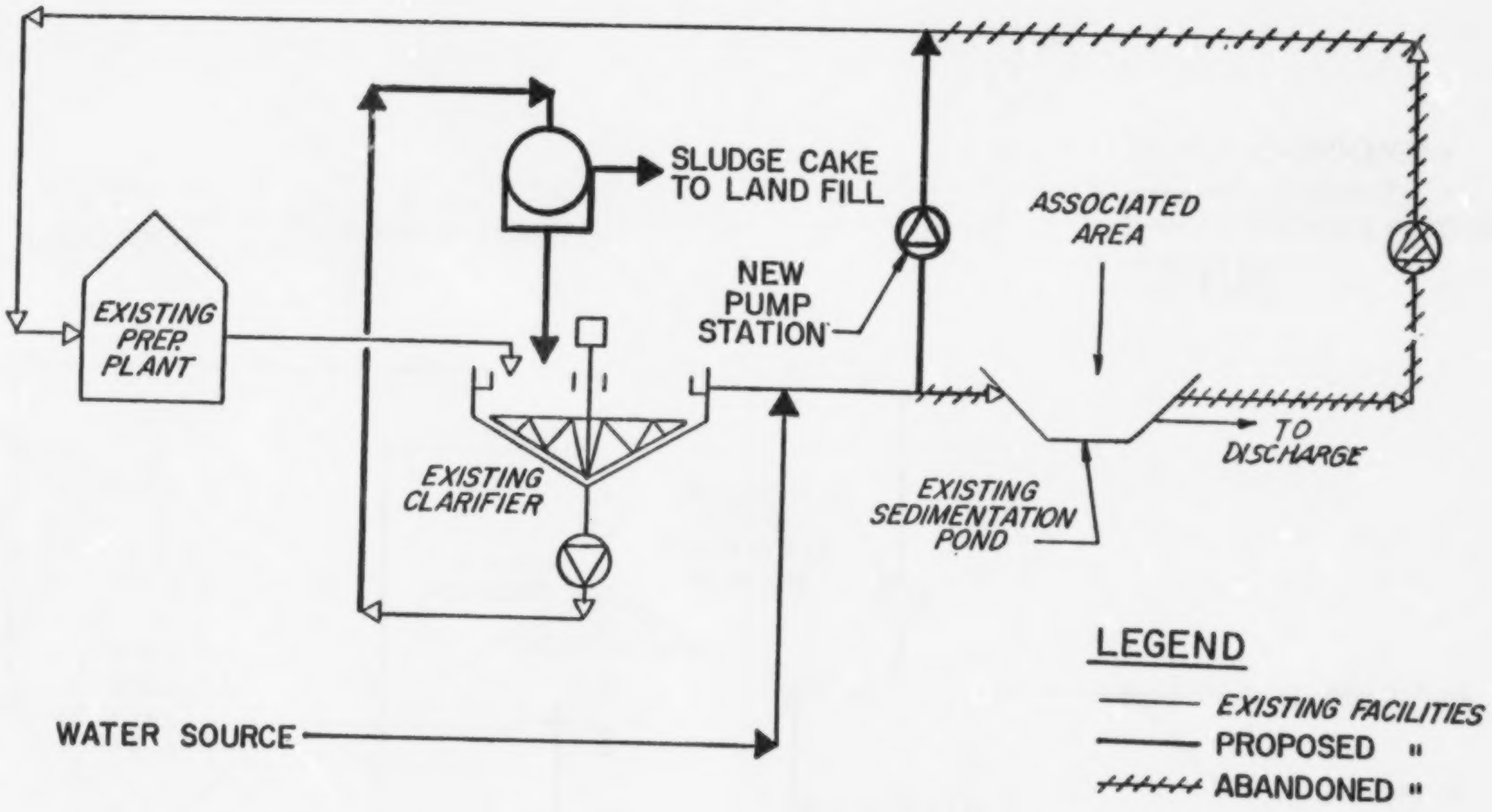

EXISTING PREP. PLANT
SLUDGE CAKE TO LAND FILL
NEW PUMP STATION
ASSOCIATED AREA
EXISTING CLARIFIER
EXISTING SEDIMENTATION POND
TO DISCHARGE
WATER SOURCE
LEGEND
EXISTING FACILITIES
PROPOSED "
ABANDONED "

Figure VIII-20

SYSTEM 3 - EXISTING PREPARATION PLANT WATER CIRCUITS

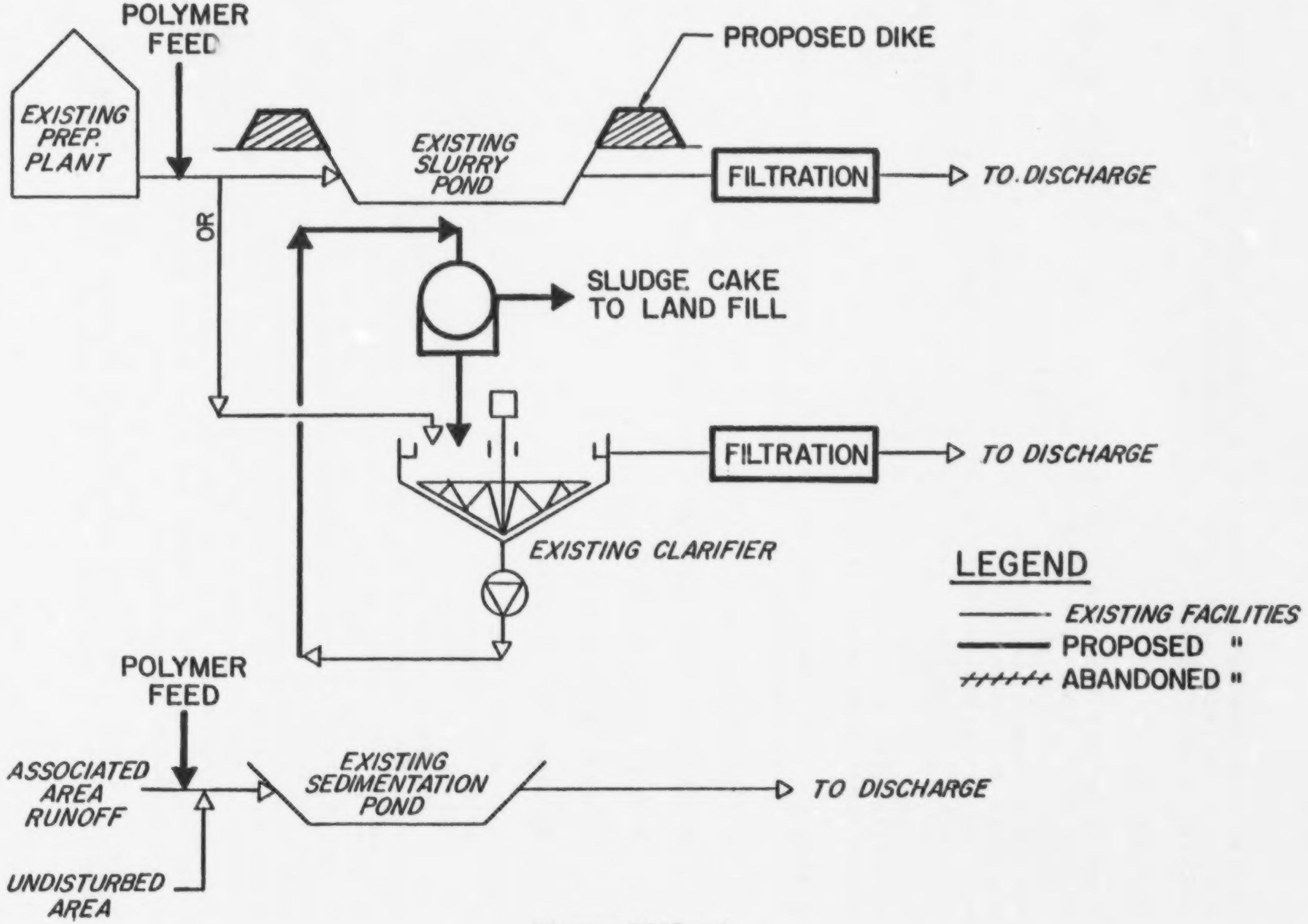

POLYMER FEED
EXISTING PREP. PLANT
PROPOSED DIKE
EXISTING SLURRY POND
FILTRATION
TO. DISCHARGE
OR
SLUDGE CAKE TO LAND FILL
FILTRATION
TO DISCHARGE
EXISTING CLARIFIER
LEGEND
EXISTING FACILITIES
PROPOSED "
ABANDONED "
POLYMER FEED
ASSOCIATED AREA RUNOFF
UNDISTURBED AREA
EXISTING SEDIMENTATION POND
TO DISCHARGE

Figure VIII-21

SYSTEM 4 - EXISTING PREPARATION PLANT - ALLOWABLE DISCHARGE either a sedimentation basin or a clarifier and then by filtration. Associated area runoff is shown as being treated separately, however, it may be commingled.

Capital Costs

Cost estimates were prepared for the components for each of the preparation plant flow configurations. These costs were then plotted with flow rate or, in the case of storm runoff, with runoff volume. The expected cost for each component includes the purchase and installation of all necessary equipment but does not include installation of power lines or access roads assumed to be in place at existing preparation plants, but needed for new sources. Since the total capital cost is very site-specific, the component costs are presented so that if the parameters of a specific site are known the total system can be costed using the appropriate component costs.

System 1. The items that may require costing for this system, depending on the particular site in question, include:

Sedimentation basin diking

Associated area drainage ditch construction

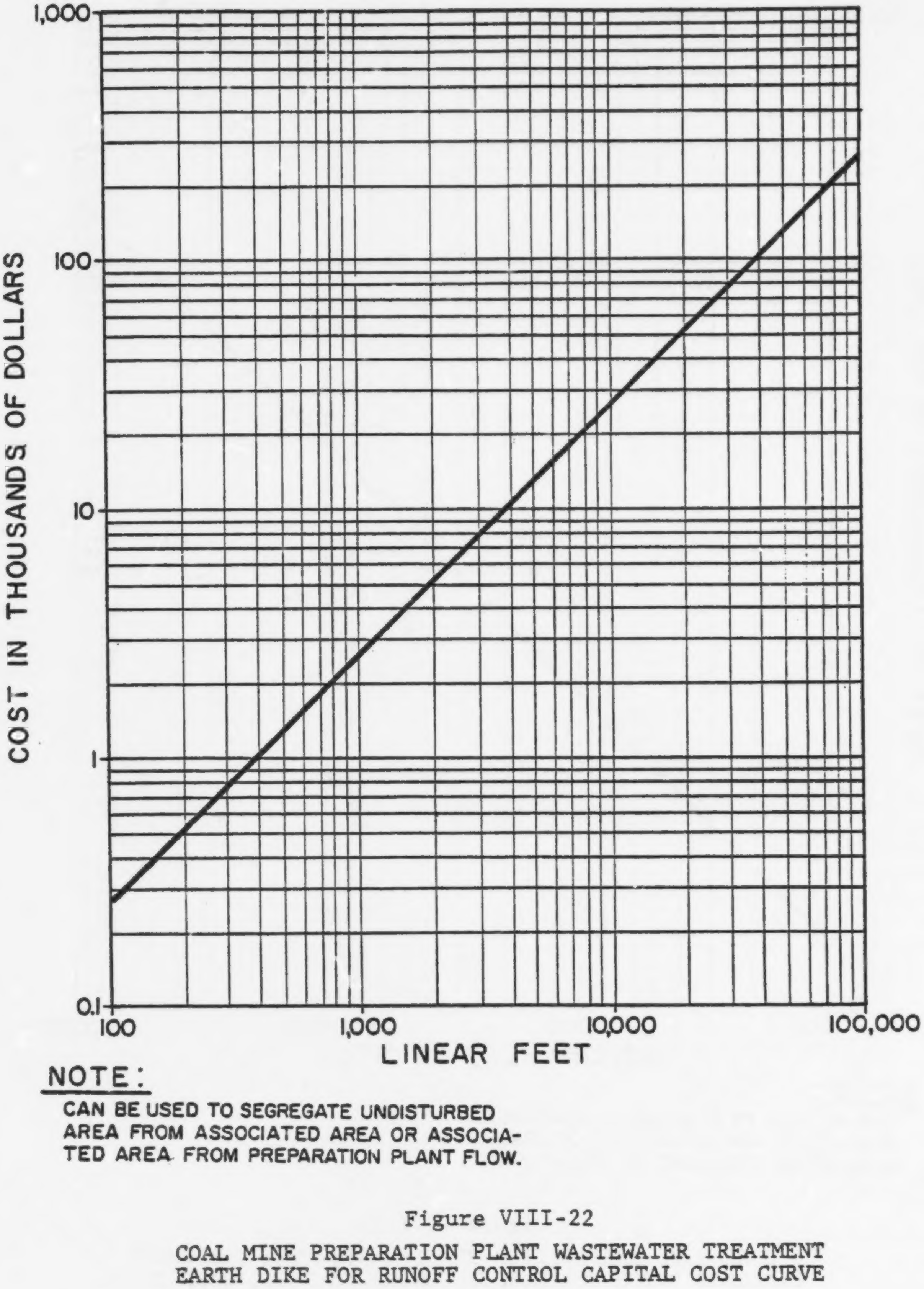
Recycle pump station

Polymer feed system

Sedimentation basins

Knowing the size and configuration of the sedimentation basin will allow the determination of the length of diking required. With this known, Figure VIII-22 can be used to determine the cost. The associated area dimensions would then be used to determine the length of drainage ditches required to segregate the undisturbed area runoff from the associated area. Figure VIII-23 is used to determine the cost of the ditches required. Figure VIII-13 is used to determine the cost of the sedimentation basin required to serve the associated area and Figure VIII-24 is used to determine the cost of a new recycle pump station. If there is a flow from the associated area during dry weather, a polymer addition system may be required so that the effluent will meet guidelines. A cost of $30,000 is estimated for flows less than 750,000 gpd and $40,000 for flow rates greater than 750,000 gpd, including an enclosure.

System 2. The items that may require costing for this system, depending on the particular site in question, include:

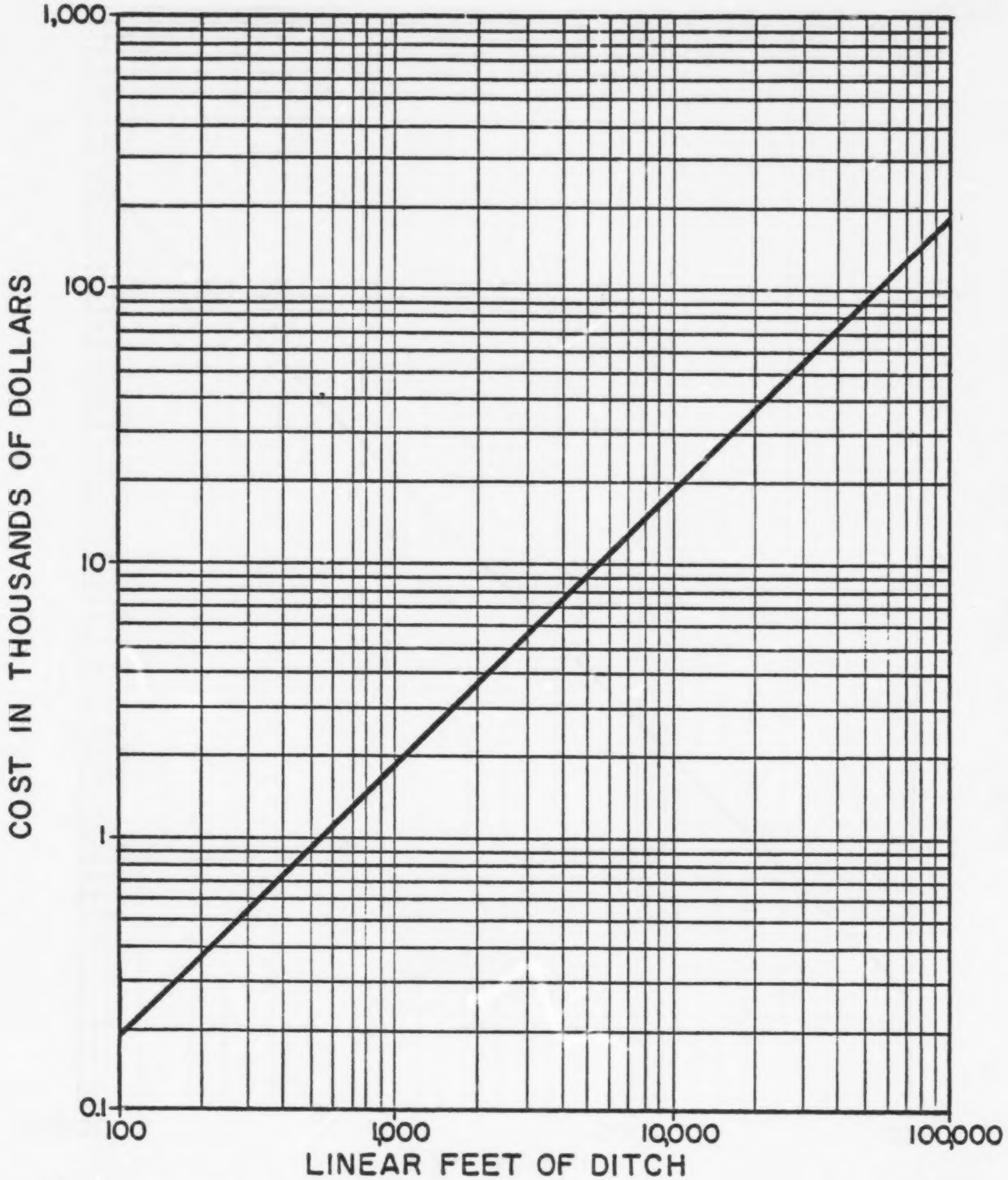


NOTE:

CAN BE USED TO SEGREGATE UNDISTURBED AREA FROM ASSOCIATED AREA OR ASSOCIATED AREA FROM PREPARATION PLANT FLOW.

Figure VIII-22

COAL MINE PREPARATION PLANT WASTEWATER TREATMENT EARTH DIKE FOR RUNOFF CONTROL CAPITAL COST CURVE



NOTE:

CAN BE USED TO SEGREGATE UNDISTURBED AREA FROM ASSOCIATED AREA OR ASSOCIATED AREA FROM PREPARATION PLANT FLOW.

Figure VIII-23

COAL MINE PREPARATION PLANT WASTEWATER TREATMENT DRAINAGE DITCH FOR RUNOFF CONTROL CAPITAL COST CURVE

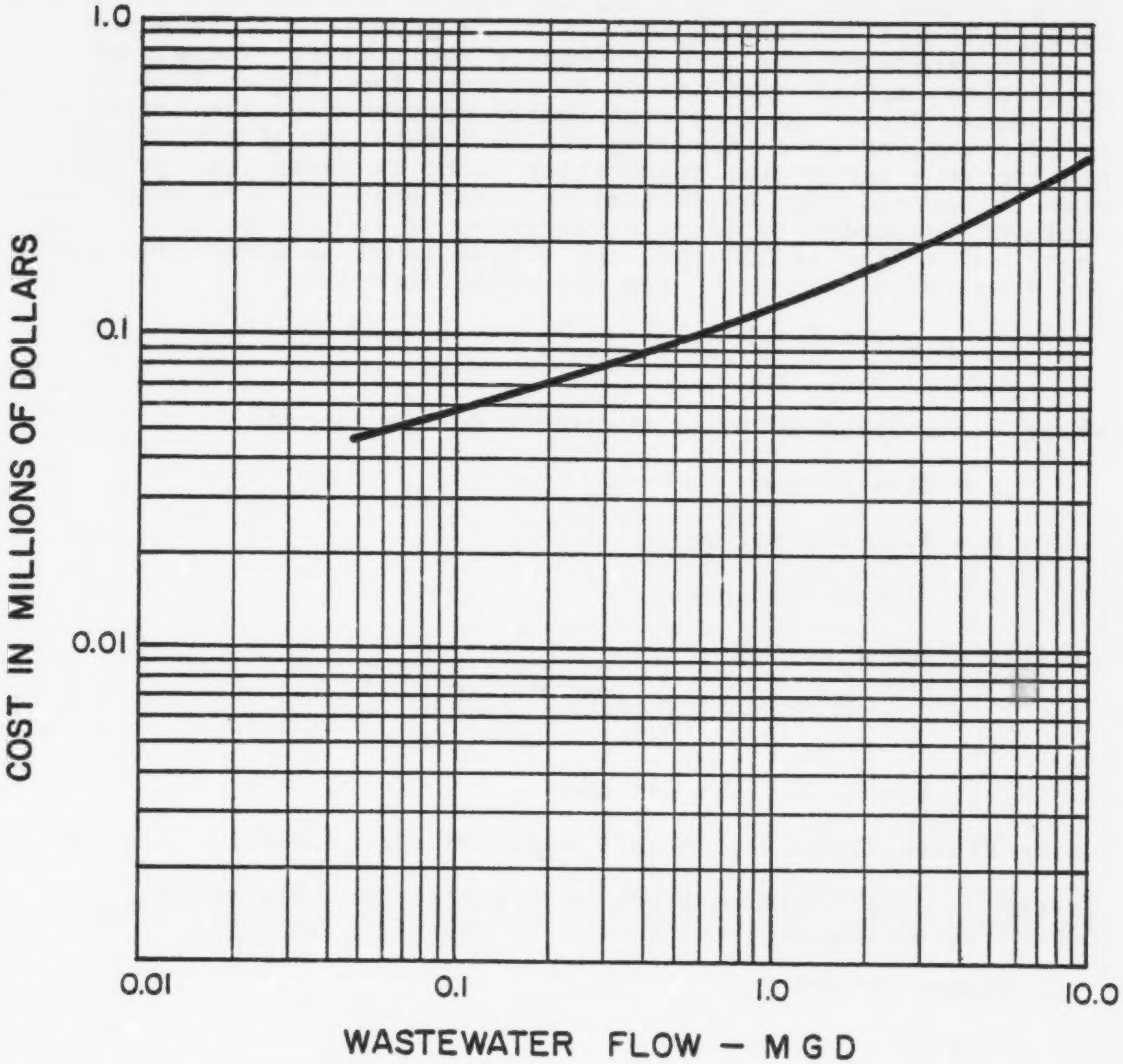


Figure VIII-24

COAL MINE PREPARATION PLANT WASTEWATER TREATMENT
RECYCLE/MAKE-UP WATER PUMPING FACILITY CAPITAL COST CURVE

Clarifier underflow dewatering

Recycle pump station

It is assumed that the existing associated area sedimentation basin will not require augmentation. Figure VIII-24 is again used to determine the cost of pumping facilities. The sludge dewatering capital cost can be determined from Figure VIII-17. The vacuum filter loading rate (based on vendor design criteria) is 50 pounds/hr/ft^2. Assuming the flow rate and slurry concentration at a particular preparation plant is known, the proper size filter can then be determined. For example, a vacuum filter influent suspended solids concentration of 100,000 mg/l (10 percent) and a flow of 250 gpm, the solids level in pounds per hour would be calculated using the following formula:

$$S = \frac{C \times F \times D \times T}{10^6}$$

where C = concentration of suspended solids in mg/l

F = flow in gpm

D = 8.34 lbs/gallon

T = time = 60 minutes.

For the example stated:

$$S = \frac{100,000 \times 250 \times 8.34 \times 60}{10^6}$$

S = 12,510 lbs per hour.

Using Figure VIII-17, the cost would be approximately $250,000.

System 3. The items that may be required for this system, depending on the particular site in question, include:

Sludge dewatering

Recycle pump station

It is assumed that the associated area sedimentation basin design will not require augmentation. Figure VIII-17 can be used to determine the cost of dewatering clarifier sludge. Figure VIII-24 can be used to determine the cost of a recycle pump station.

System 4. The items that may be required for the system, depending on the particular site in question, include:

Sedimentation basin - diking

Sludge dewatering

Polymer feed and granular media filtration

This system assumes an allowable discharge from the preparation plant without recycle using either existing sedimentation basins or clarifiers. The sludge dewatering cost, if required, can be obtained from Figure VIII-17. In order to meet effluent limitations, a polymer feed may be required before the preparation plant slurry pond or the clarifier. The capital cost for polymer feed equipment is $30,000 for flows up to 750,000 gpd and $40,000 for flows over 750,000 gpd. If filtration is required to meet effluent limitations its cost can be found in Figure VIII-6.

Annual Costs

Since the components for the various systems described above and the annual costs to operate and amortize these components are the same, the annual costs are presented only once. Once the need for a component in a particular system is determined, the annual cost is derived from the following figures:

	Figure
Annual Costs of Dikes & Ditches	VIII-25
Annual Costs of Recycle Pump Station	VIII-26
Annual Costs of Sedimentation Basins	VIII-15
Annual Costs of Sludge Dewatering	VIII-27
Annual Costs of Clarifier	VIII-28

All the component annual costs are additive for a given system.

New Sources

Zero Discharge from Preparation Plant Water Circuit

System 1. This system assumes a new source using a pond to treat the preparation plant discharge prior to 100 percent recycle. A separate pond designed to contain the runoff from a 10-year, 24-hour storm would be used for associated area runoff. The associated area and pond would be ditched to divert an undisturbed area runoff from associated area runoff. Figure VIII-29 is a schematic of this system.

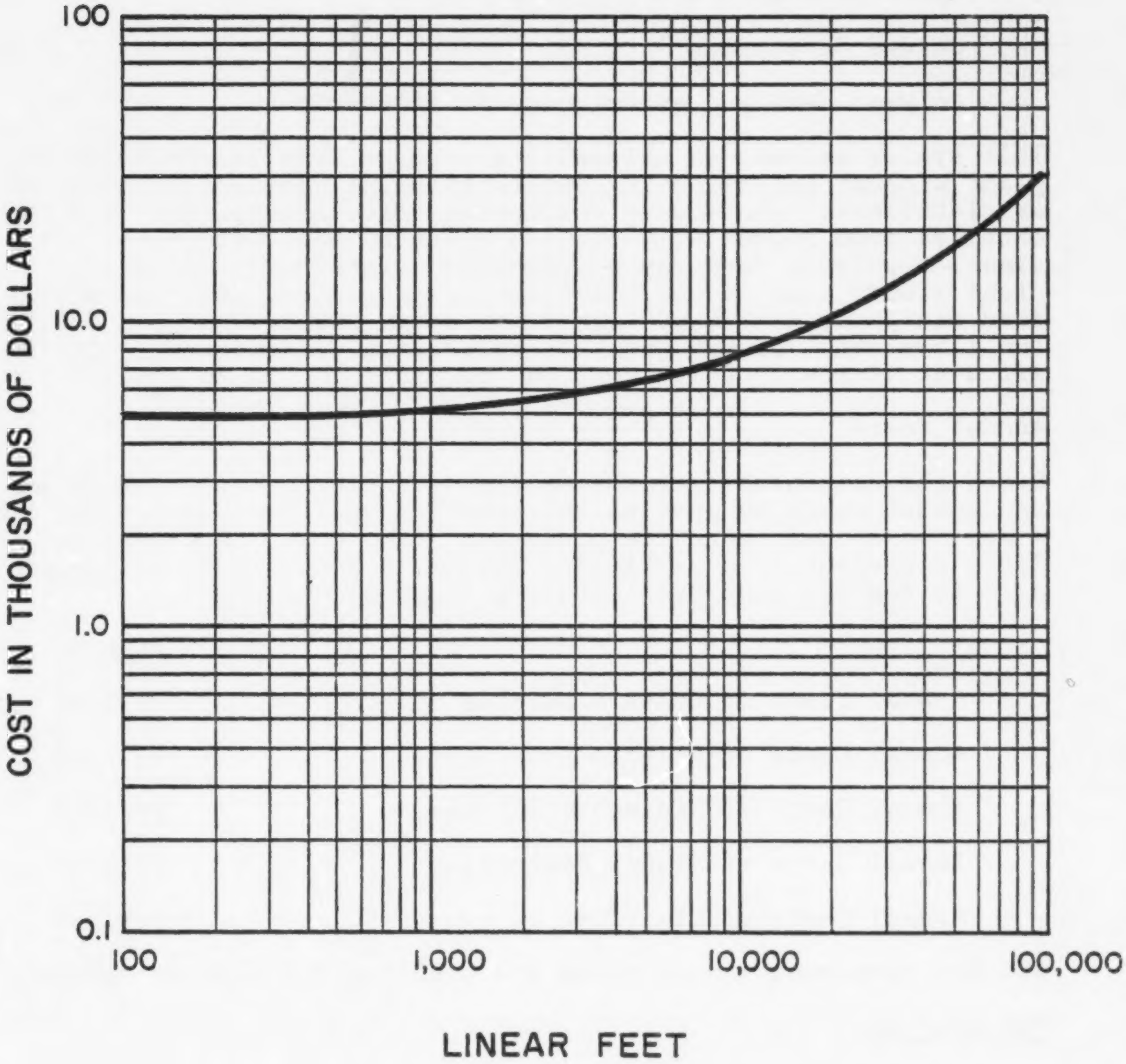


Figure VIII-25

WASTEWATER TREATMENT EARTH DIKE/DRAINAGE DITCH FOR RUNOFF CONTROL ANNUAL COST CURVE

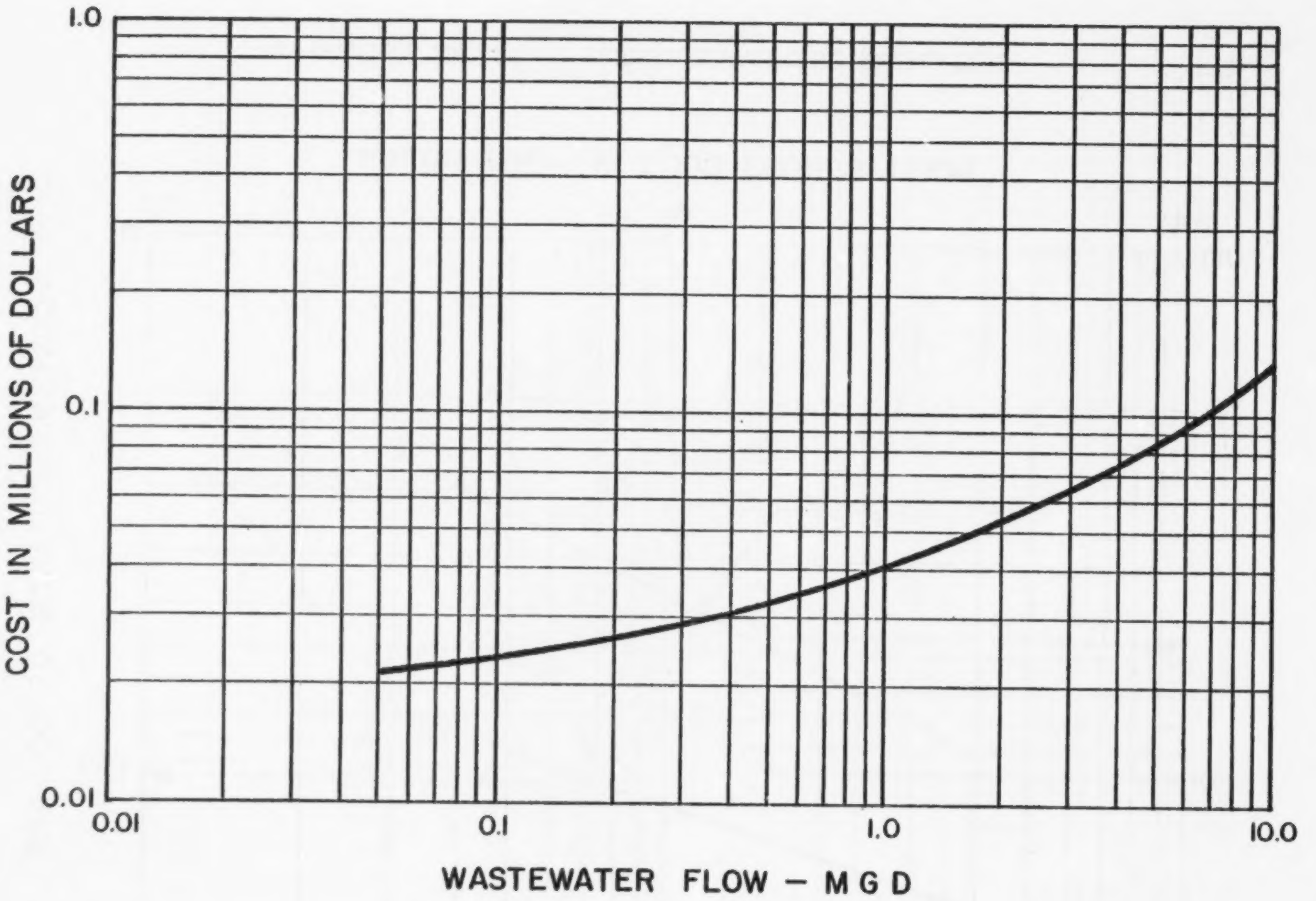


Figure VIII-26

WASTEWATER TREATMENT RECYCLE/MAKE-UP WATER PUMPING FACILITIES ANNUAL COST CURVE

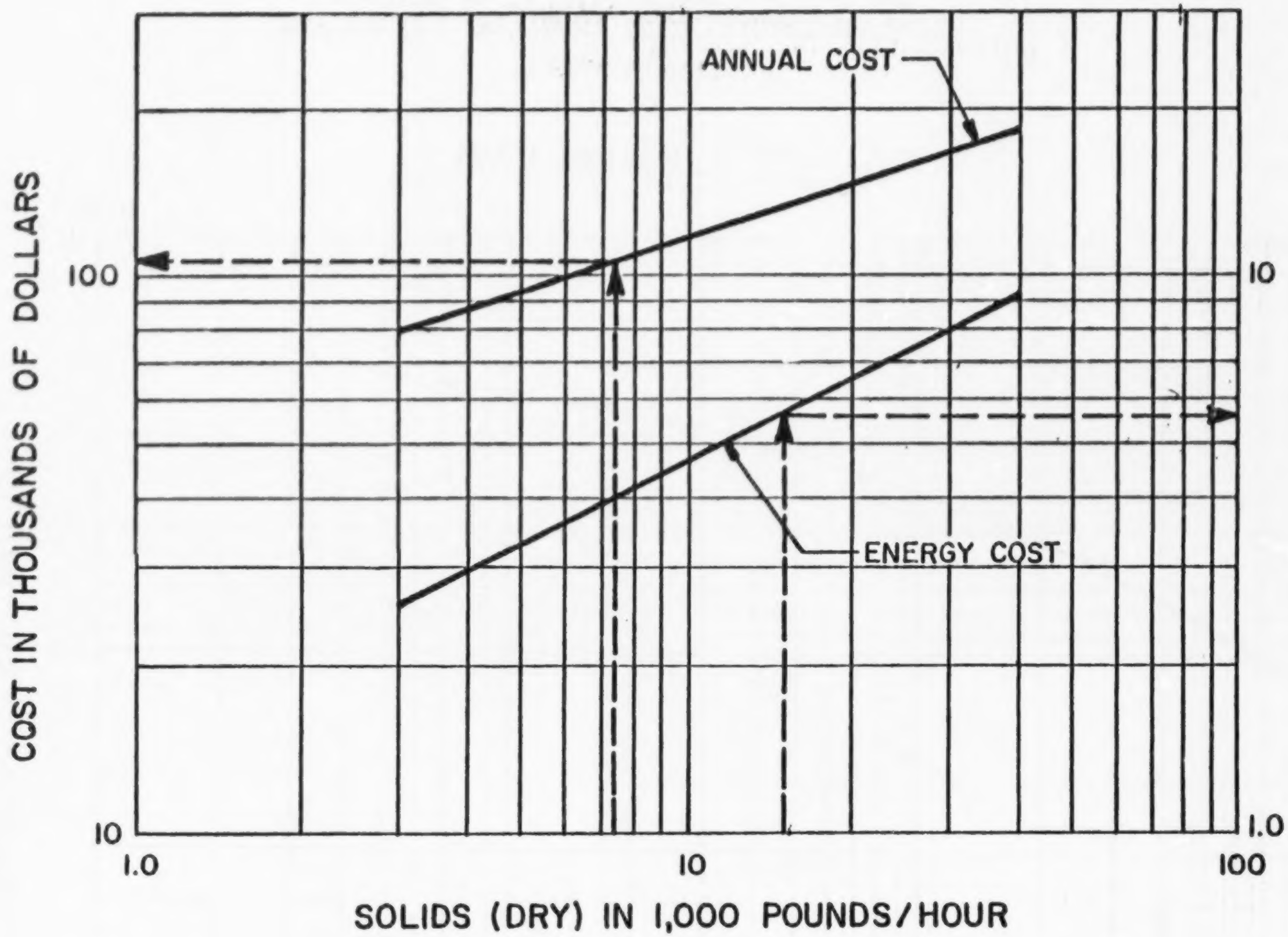


Figure VIII-27
WASTEWATER TREATMENT SLUDGE DEWATERING FACILITIES
ANNUAL COST CURVE

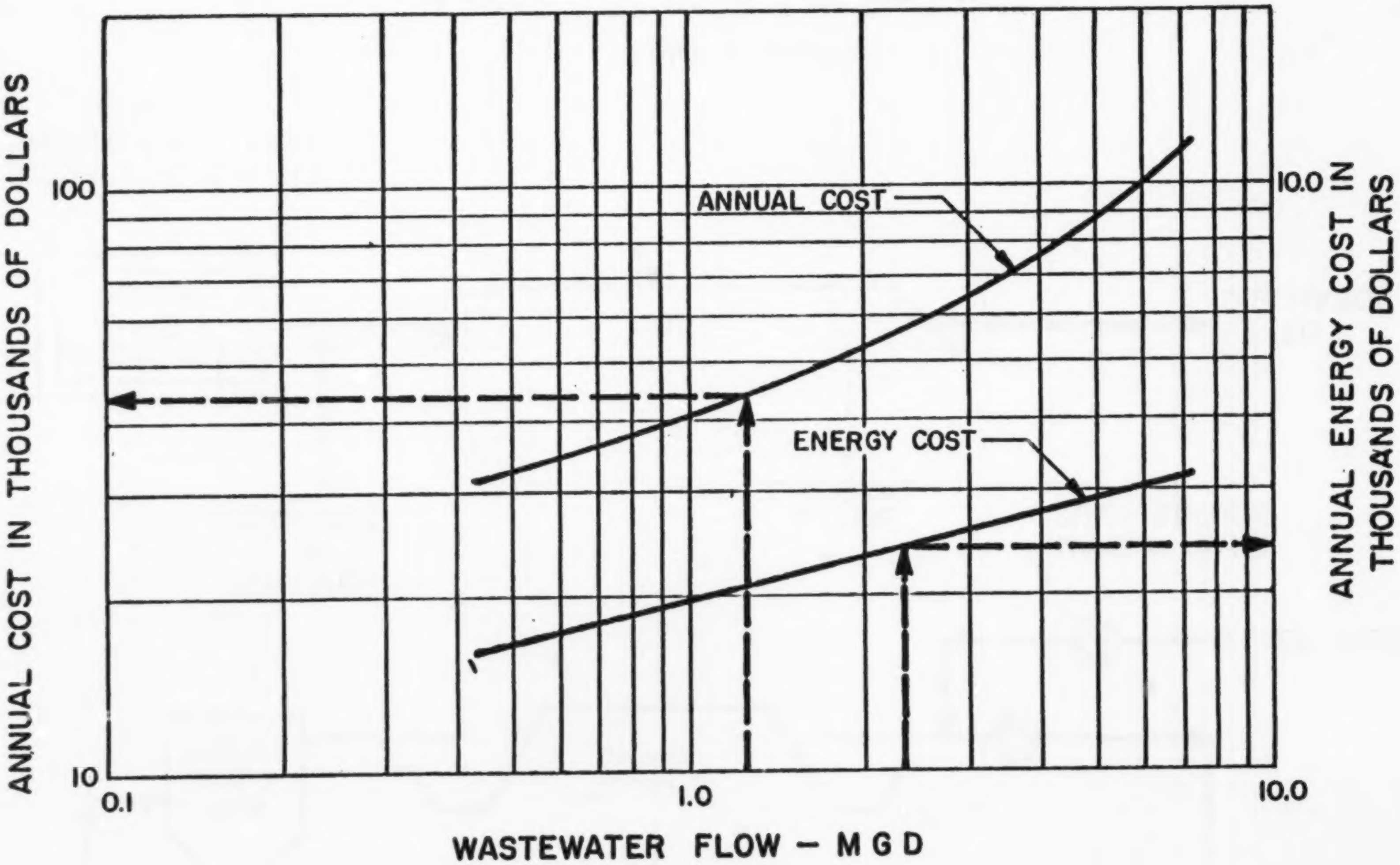


Figure VIII-28
WASTEWATER TREATMENT CLARIFIER AND PUMP STATION
ANNUAL COST CURVE

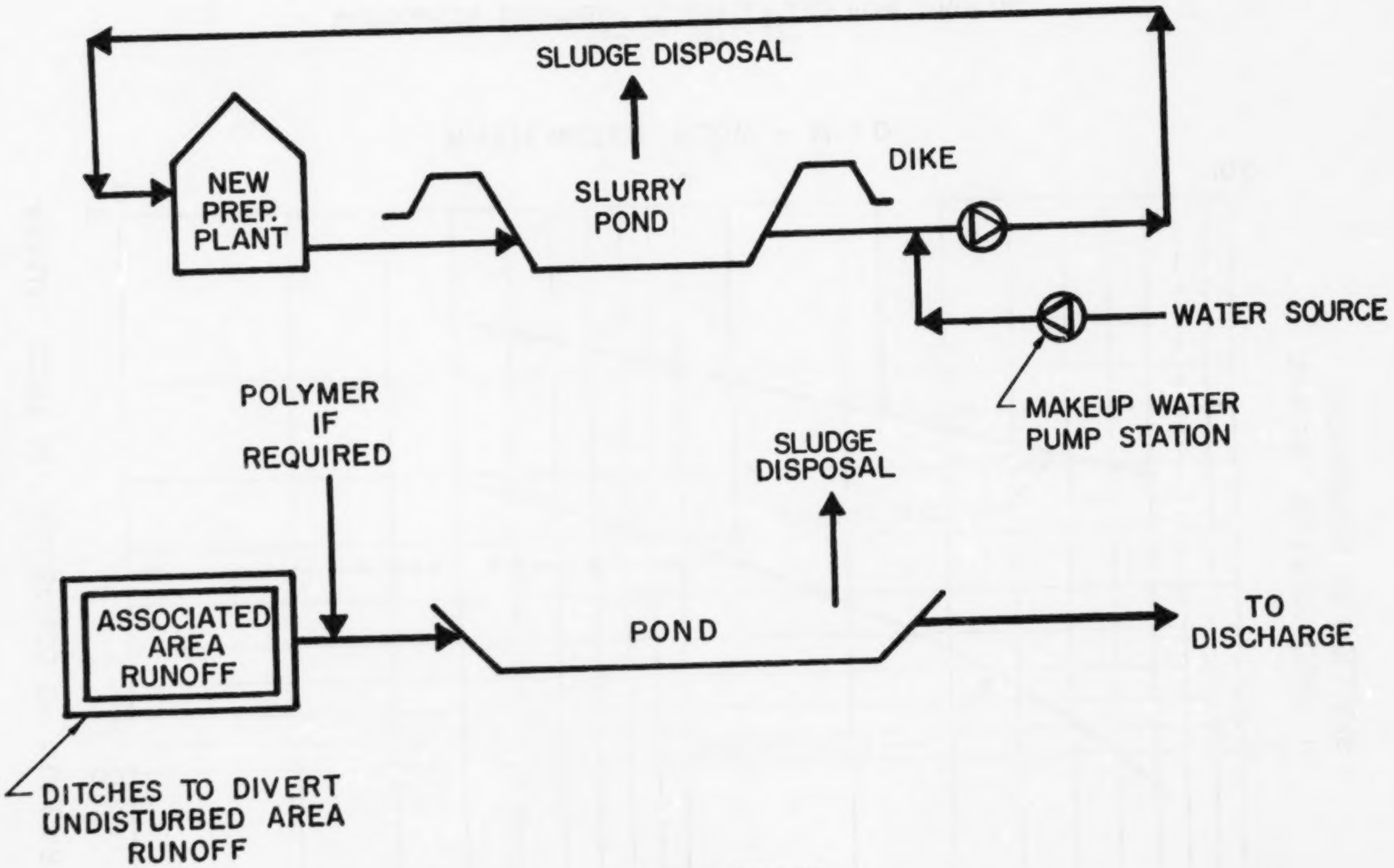

SLUDGE DISPOSAL
NEW PREP. PLANT
SLURRY POND
DIKE
WATER SOURCE
MAKEUP WATER PUMP STATION
POLYMER IF REQUIRED
SLUDGE DISPOSAL
ASSOCIATED AREA RUNOFF
POND
TO DISCHARGE
DITCHES TO DIVERT UNDISTURBED AREA RUNOFF

Figure VIII-29

SYSTEM 1 - NEW SOURCE WATER CIRCUITS

System 2. This system assumes a new source using a clarifier to treat the preparation plant discharge prior to 100 percent recycle. A separate pond designed to contain the runoff from a 10-year, 24-hour storm would be used for associated area runoff. The associated area and pond would be ditched to divert undisturbed area runoff from associated area runoff. Figure VIII-30 is a schematic of this system.

Capital Costs

System 1. This system, as shown in Figure VIII-29, is applied to new sites where all treatment facilities are constructed when the preparation plant is constructed. A slurry pond for the preparation plant wastewater would be installed and a pump station for 100 percent recycle of the treated water required. Associated area runoff would be segregated from the undisturbed area. The items required for this system include:

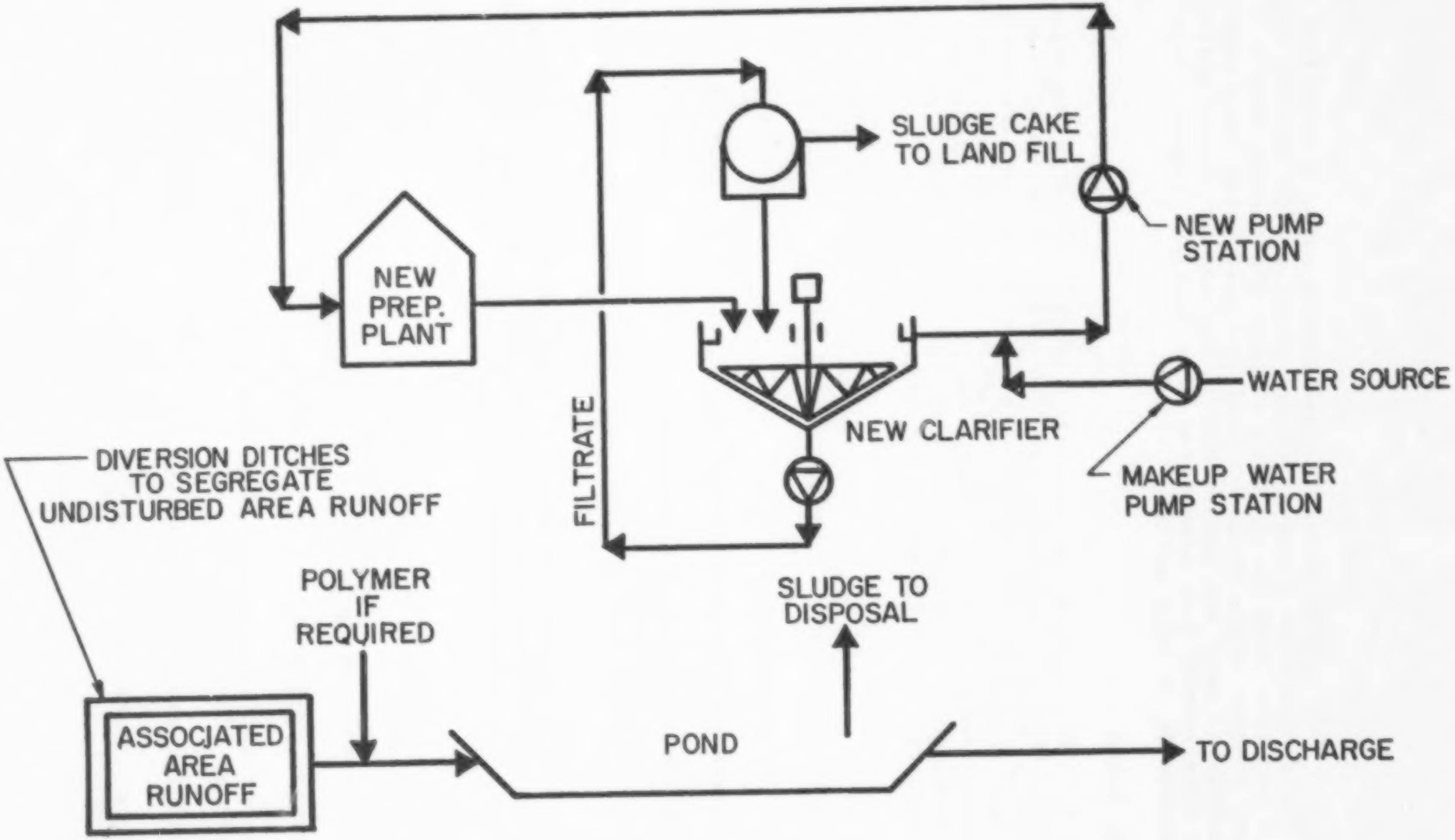
	Figure
Preparation plant slurry pond with dikes	VIII-13 & VIII-22
Recycle pump station	VIII-24
Associated area segregation by ditch	VIII-23
Pond for associated area runoff	VIII-13

The figure numbers next to the items can be used to determine the capital costs.

System 2. This system, as shown in Figure VIII-30, is applied to new sites when a clarifier is used to treat the preparation plant discharge. The items required for this system include:

	Figure
Clarifier	VIII-31
Sludge dewatering	VIII-17
Recycle pump station	VIII-24
Associated area segregation from undisturbed area by ditch	VIII-23
Pond for associated area runoff	VIII-13 & VIII-22

The figure numbers next to the items can be used to determine the capital costs.


SLUDGE CAKE TO LAND FILL
NEW PUMP STATION
NEW PREP. PLANT
WATER SOURCE
NEW CLARIFIER
MAKEUP WATER PUMP STATION
FILTRATE
DIVERSION DITCHES TO SEGREGATE UNDISTURBED AREA RUNOFF
POLYMER IF REQUIRED
SLUDGE TO DISPOSAL
ASSOCIATED AREA RUNOFF
POND
TO DISCHARGE

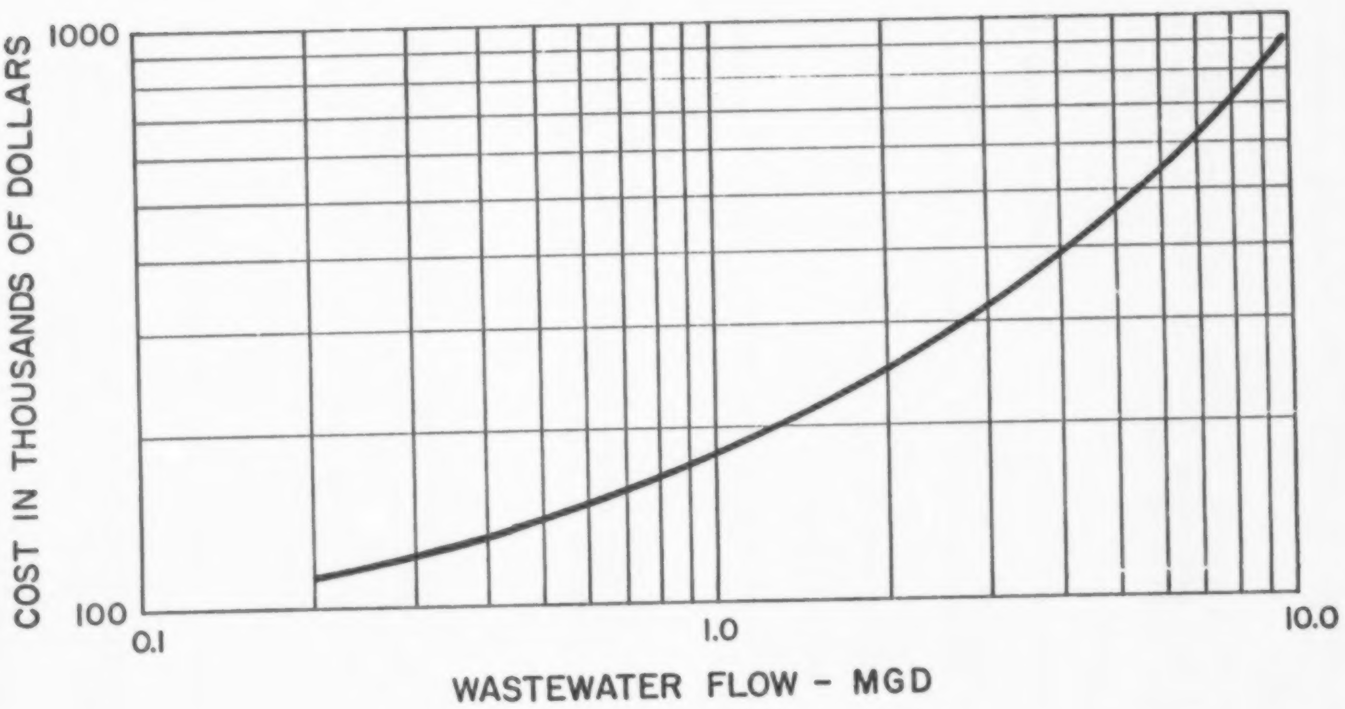


Figure VIII-31

WASTEWATER TREATMENT CLARIFIER
AND PUMPING FACILITIES CAPITAL COST CURVE

Annual Costs

For both new source systems, the annual costs can be derived from the same annual cost curves presented for existing sources.

POST MINING DISCHARGES

Operation and maintenance costs to treat post mining discharges through bond release are presented in this section. (Note: this treatment is already required by OSM.)

General Assumptions Used

In determining the treatment costs, five assumptions were made:

1. No capital charges are included. It is assumed facilities are fully depreciated by the time of mine closure.

2. No "typical" pond size could be assumed. Ponds range from "no pond" to 21 acre-feet in storage.

3. A "typical" lime dosage is 300 mg/l.

4. Operation and maintenance and energy costs for lime feeding are not sensitive to lime dosage rates and are assumed constant.

5. Sludge pumping energy costs are less than five percent of the total operation and maintenance costs. Therefore, energy costs for varying sludge rates are masked by the total operation and maintenance cost.

Reclamation Areas

These costs apply only to surface mines. The costs include sedimentation structures for treating the runoff from areas under reclamation through release from the applicable reclamation bond. For this subcategory, treatment is for the control of settleable solids and pH.

Assumptions

In determing the treatment costs, two assumptions were necessary:

1. Since OSM requires treatment facilities for areas under reclamation to meet BPT limitations, no capital costs result from these requirements.

2. Lime for pH control should not be required for discharges covered in the reclamation phase since no acid wastewater

should be formed at these facilities. Again, this has been verified by an Agency study of reclamation areas.

Operation and Maintenance Costs

The costs associated with areas under reclamation include operation and maintenance costs for sedimentation ponds and maintenance costs for runoff control with earth dikes or drainage ditches. The cost curves for these areas are identical to figures previously presented, but are repeated here for convenience. Figure VIII-32 presents operation and maintenance costs for sedimentation ponds. The capital cost of the pond was found in Figure VIII-13. The maintenance costs for runoff control with earth dikes or drainage ditches are given in Figure VIII-33. Supporting information and assumptions for developing these figures may be obtained in Appendix A.

Alkaline Underground Mines

Only settling ponds are considered for costing. No clarifiers have been included because few alkaline deep mines employ clarifiers for wastewater treatment. The annual operation and maintenance cost curve for wastewater treatment with settling ponds was presented in Figure VIII-32. The annual maintenance cost curve for earth dike or drainage ditch runoff control was illustrated in Figure VIII-33. Supporting information and assumptions for developing these figures may be found in Appendix A.

Acid Underground Mines

Two treatment systems are considered for costing. The first system includes settling ponds, lime addition equipment, and aeration equipment. The second system includes clarifiers, lime addition equipment, and aeration equipment.

Costs Associated with Both Settling Pond and Clarifier Systems. The annual costs associated with both systems may be obtained from Figures VIII-34, VIII-35, and VIII-36. Included in the cost curves of Figure VIII-36 is the cost of hydrated lime at $65 per ton. Supporting information and assumptions for developing these figures may be found in Appendix A.

Costs Associated Only with the Settling Pond System. Operation and maintenance costs were illustrated in Figures VIII-32 and VIII-33. The total operation and maintenance costs for the sedimentation pond system (including sedimentation ponds, lime addition and aeration) are determined by adding the costs from Figures VIII-32 and VIII-33 to the costs obtained from Figures VIII-34, VIII-35, and VIII-36.

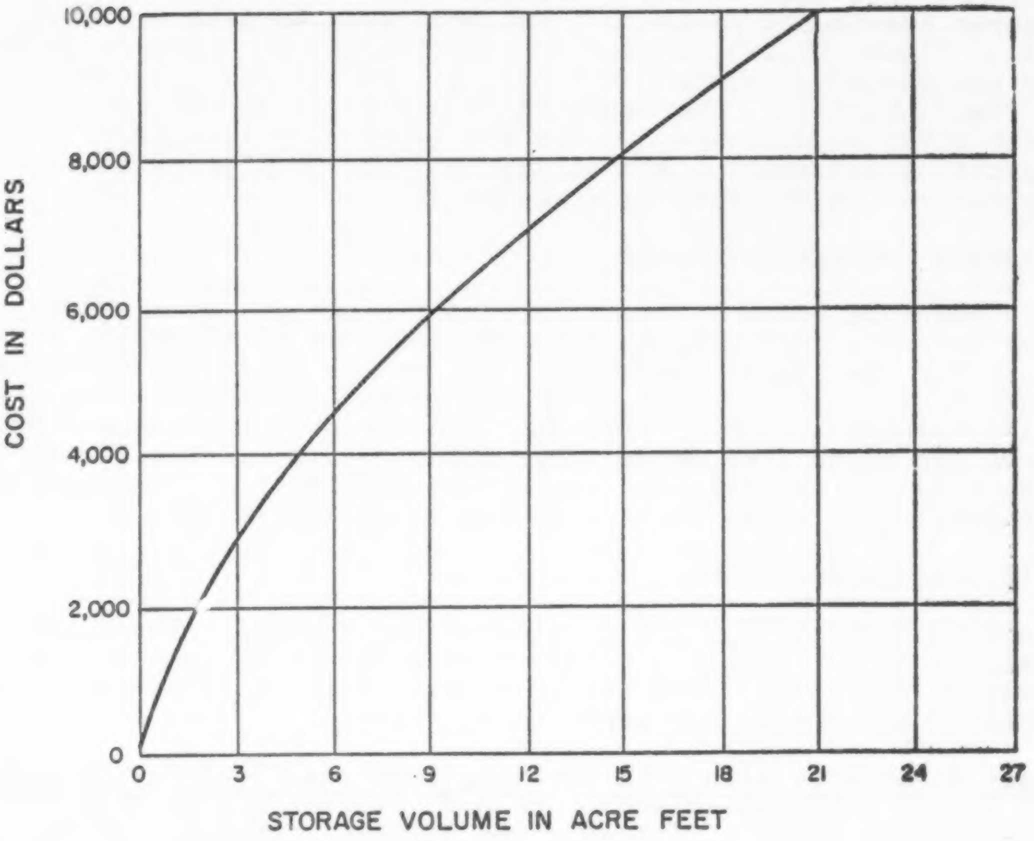


Figure VIII-32

SEDIMENTATION POND OPERATION AND MAINTENANCE
ANNUAL COST CURVE FOR POST MINING DISCHARGES

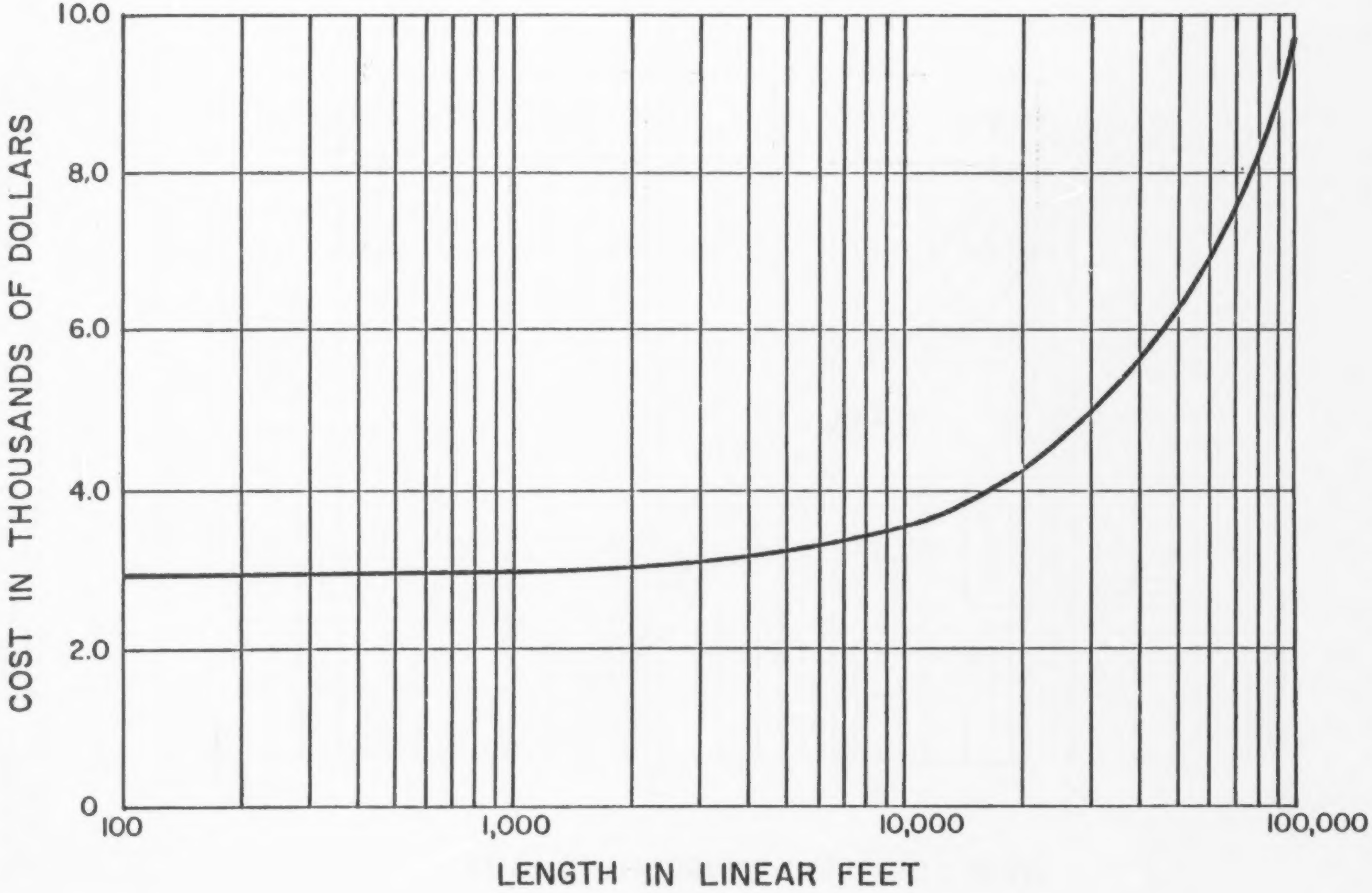


Figure VIII-33

ANNUAL MAINTENANCE COST CURVE FOR EARTH DIKE/DRAINAGE DITCH RUNOFF CONTROL FOR POST MINING DISCHARGES

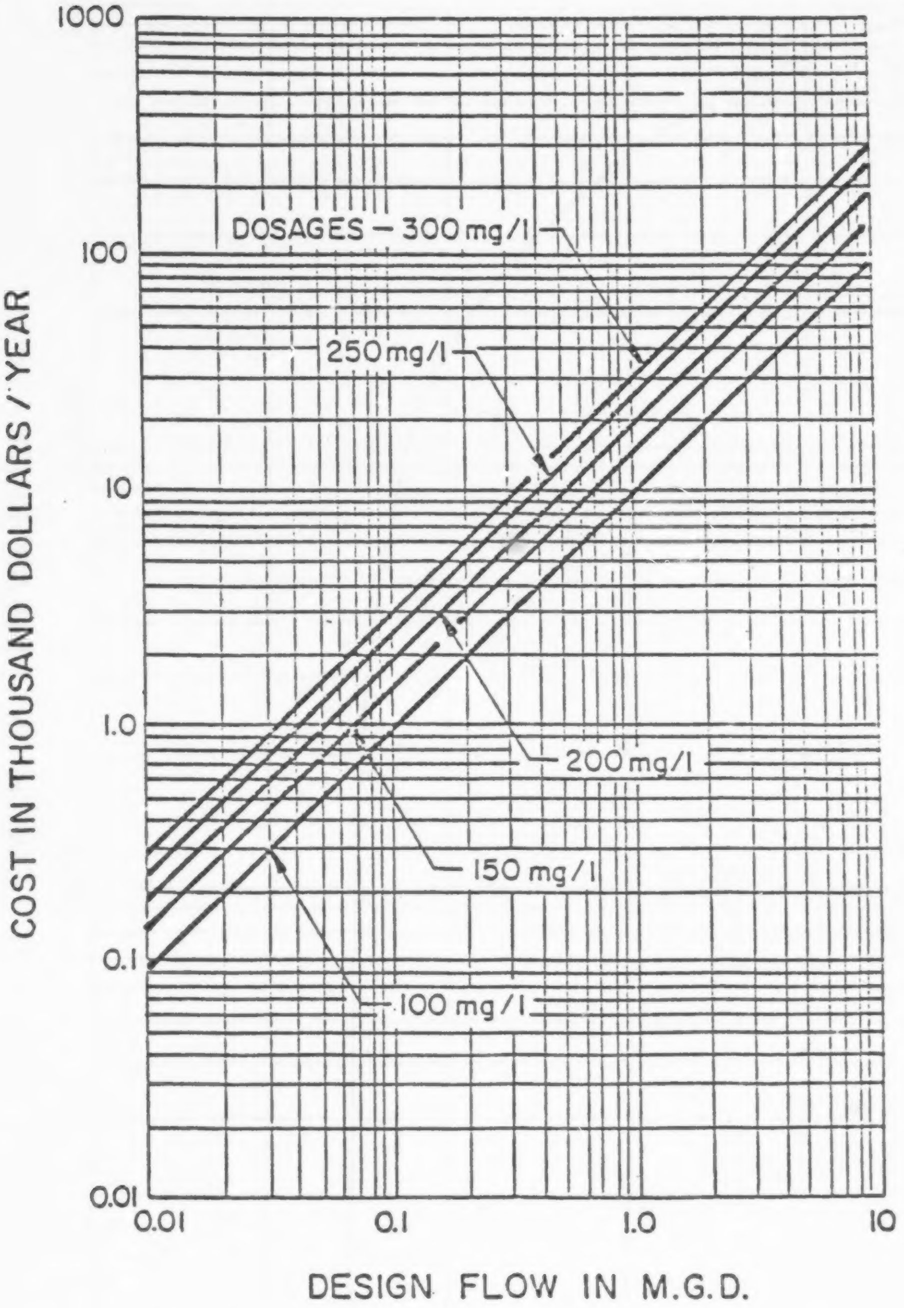


Figure VIII-34

POST MINING DISCHARGE LIME ADDITION CHEMICAL COST CURVES FOR UNDERGROUND COAL MINE ACID WASTEWATER TREATMENT WITH SEDIMENT PONDS OR CLARIFIERS

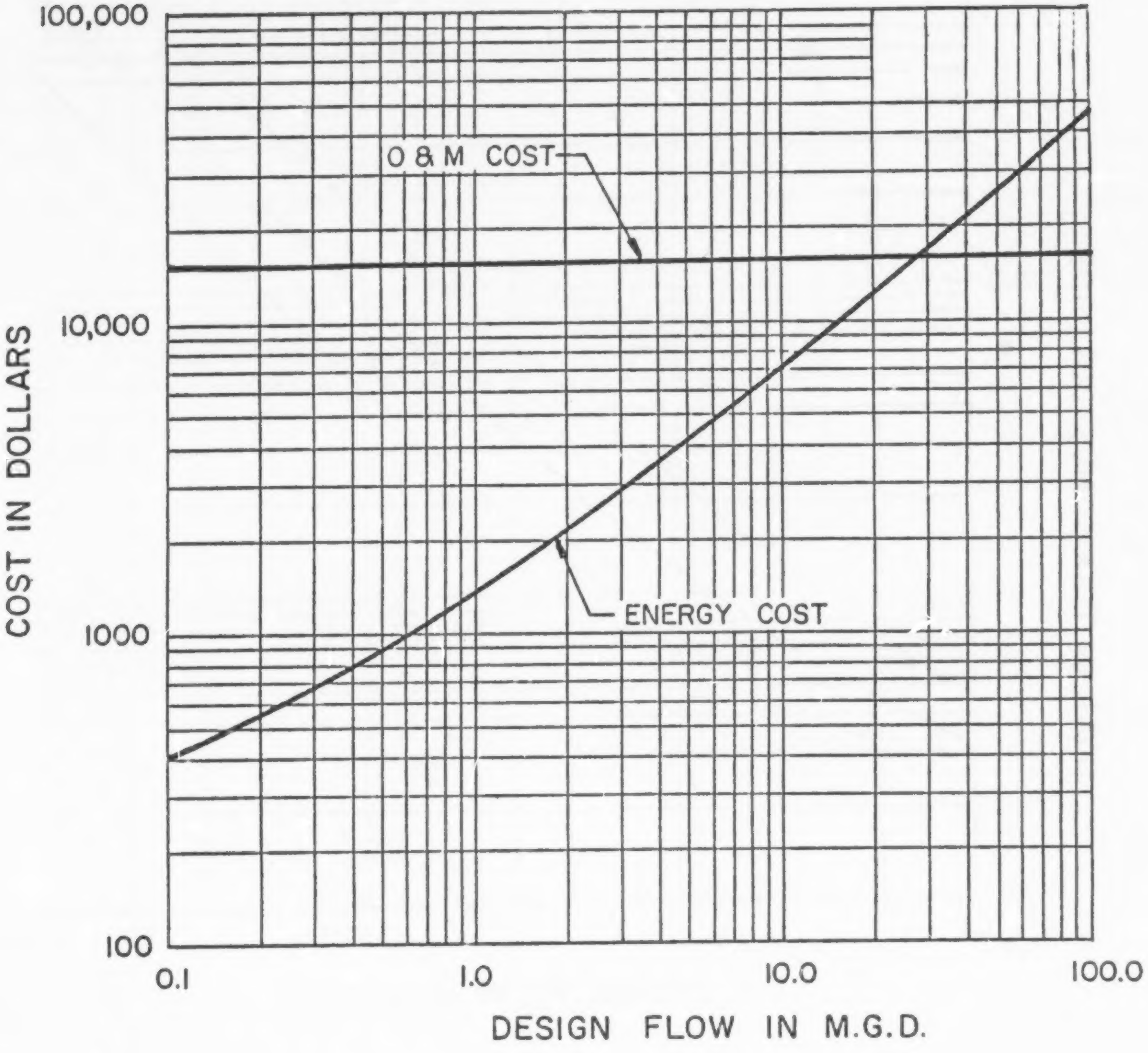


Figure VIII-35

POST MINING DISCHARGE LIME FEED FACILITIES OPERATION AND MAINTENANCE ANNUAL COST CURVES FOR UNDERGROUND COAL MINE ACID WASTEWATER TREATMENT WITH SEDIMENTATION PONDS OR CLARIFIERS

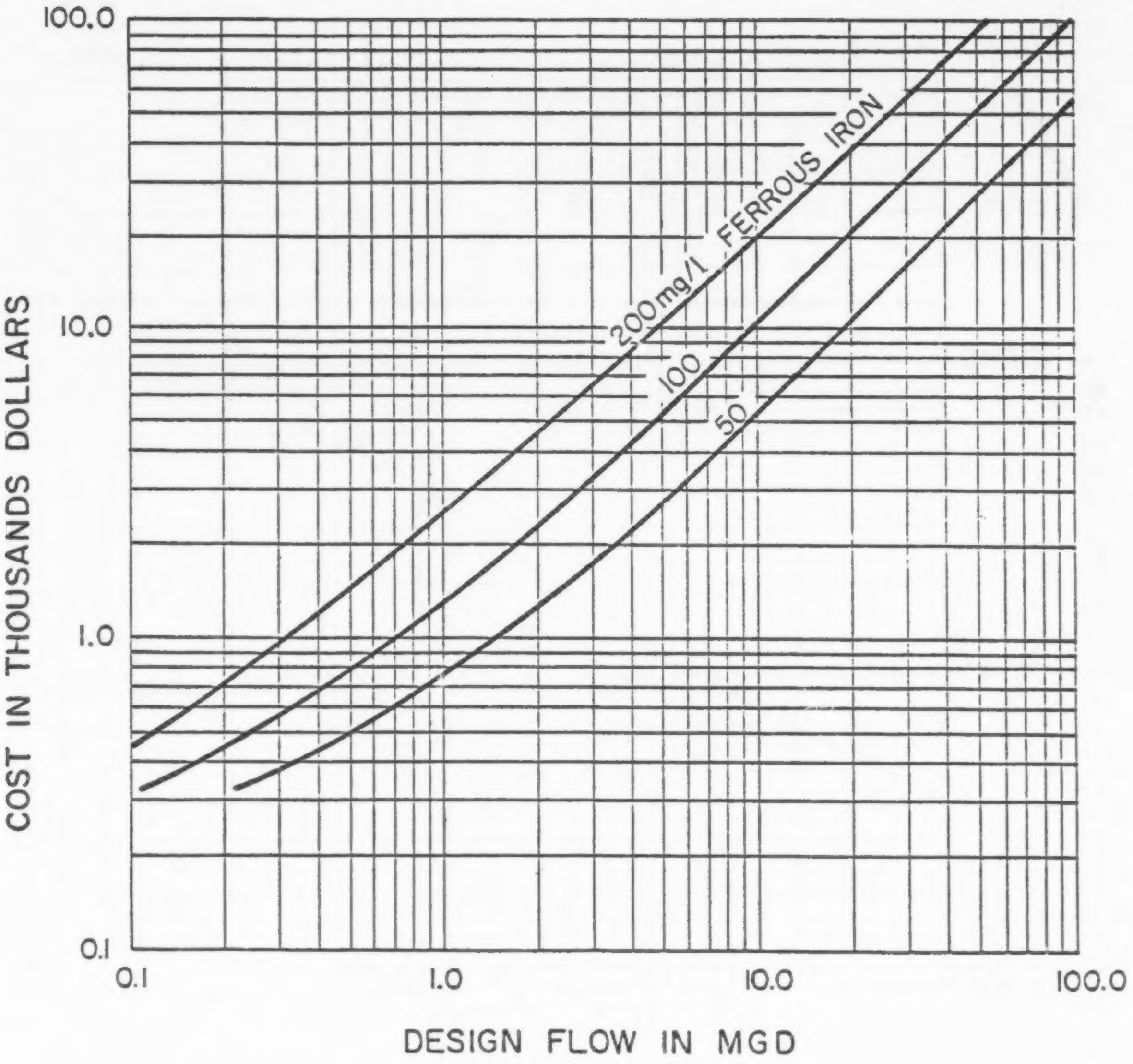


Figure VIII-36

POST MINING DISCHARGE AERATION OPERATION AND MAINTENANCE ANNUAL COST CURVE FOR UNDERGROUND COAL MINE ACID WASTEWATER TREATMENT WITH SEDIMENTATION PONDS OR CLARIFIERS

Costs Associated Only with the Clarifier System. The clarifier and sludge pumping operation and maintenance costs are presented in Figure VIII-37. To obtain the total operation and maintenance costs for the clarifier system (including clarifiers, lime addition, and aeration), add the costs from Figure VIII-37 to the costs obtained from Figures VIII-34, VIII-35, and VIII-36.

GENERAL ASSUMPTIONS UNDERLYING CAPITAL COSTS FOR ALL SUBCATEGORIES

Building Costs

Buildings will be required to house chemical and polymer feed equipment, as well as the controls for the treatment systems. The cost estimates were prepared by including various subcategories, i.e., costs for concrete, superstructure, plumbing, sanitation, and lighting. The electrical and control panel costs as well as laboratory facilities and office equipment are included in the building costs. These costs are included in the capital cost curves for each of the treatment levels.

Piping

The type of piping costed for each treatment system is carbon steel. Pipe diameters were sized based on six to seven feet per second flow velocity. The costs for piping were based on up-to-date pipe cost quotations and a factor of 100 percent was added to this cost to account for fittings, flanges, hangers, excavation, and backfilling as required.

Electrical and Instrumentation

The electrical and instrumentation costs for the treatment levels were estimated at 30 percent of the cost of the applicable equipment.

Power Supply for Mine Water Treatment

Operation of the equipment associated with the three candidate levels of BAT treatment may require additional electric power at the site. This power can be supplied by either running a power line from an accessible trunk line or power source, or by using diesel powered generator units. The worst case would probably be to run a high voltage trunk line from a generating facility long distances to the wastewater treatment facility. In addition to the capital cost for power line construction, associated costs for metering, transformers and secondary lines would be required.

In order to provide information on the costs for running power lines, two supply voltage levels were assumed: 480 volts and

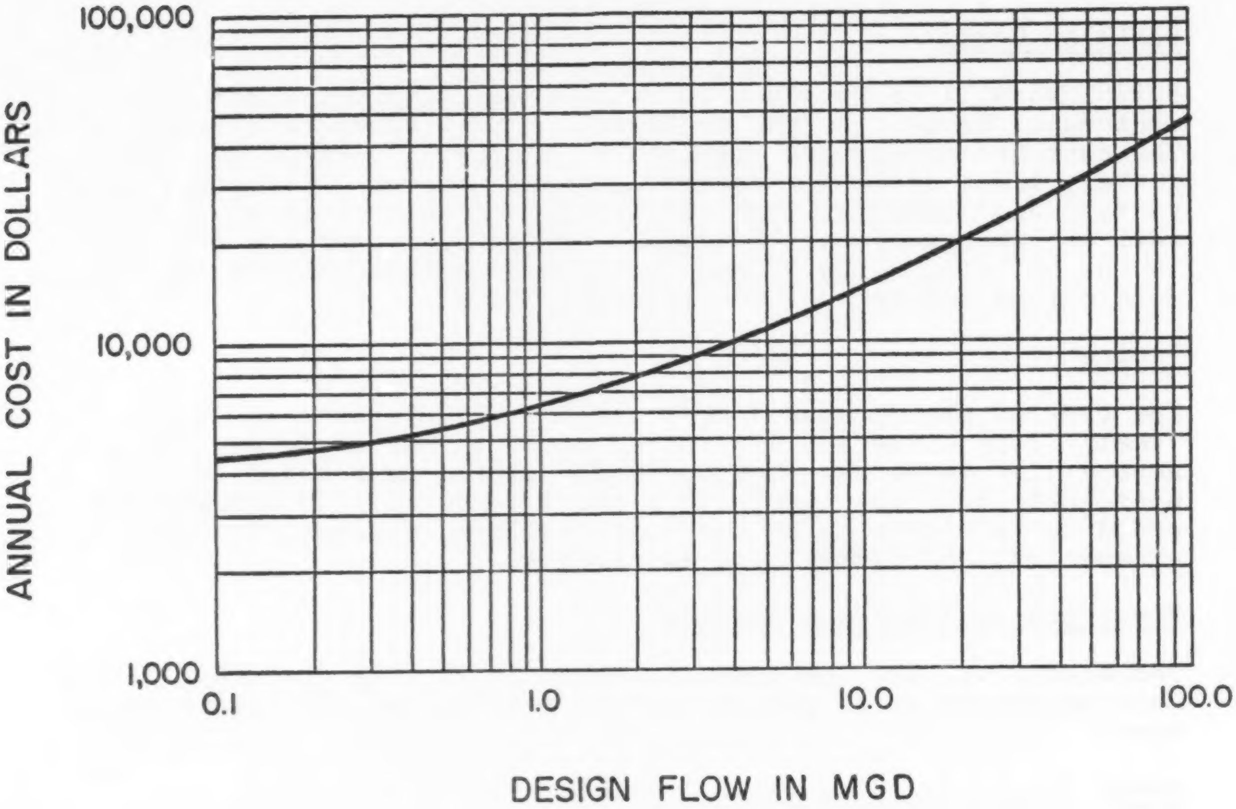


Figure VIII-37

AFTER MINE CLOSURE CLARIFIER MECHANISM AND
SLUDGE PUMPING OPERATION AND MAINTENANCE
ANNUAL COST CURVE FOR UNDERGROUND COAL MINE
ACID WASTEWATER TREATMENT WITH CLARIFIERS

4.16 kilovolts. It was then assumed that the practical breakpoint on transmission distance would be between 500 to 1,000 feet for 480 volts. Distances approaching 1,000 feet and longer would require a feeder of 4.16 kV. Table VIII-4 has been prepared to present approximate cost for power lines. If the distance from the source and user and the load in kilowatts (kW) is known, the table can be used to obtain the power line costs. These prices include installation, poles, wire, insulators and crossarms for 480 volts and also includes a power center at the user containing a high voltage incoming section with necessary protection disconnecting devices, transformer (4.16 kV/480V) and secondary side circuit breaker.

In cases where trunk or secondary lines are not readily available, it may be advantageous to operate diesel engine generator units. The range of approximate power requirements for the three candidate levels of BAT is from 5 kw at the lowest flow rate, level 2, to 150 kw for the highest flow rate, level 4. An economic tradeoff exists between the relatively low capital cost for a diesel unit and the relatively low maintenance and operating costs of a long distance trunk line system. Table VIII-5 provides cost estimates for diesel generator units for a range of power requirements. The costs presented in Table VIII-5 include an ICC approved weather-housed trailer with controls, cables, battery muffler system, alternator, control panel, silencer, diesel engine, and generator. Capital costs for electric power supply do not include land requirements and are not included in the capital cost curves presented for the various treatment levels, due to the highly site-specific nature of these costs. No extensive power requirements are necessary at the preparation plants since power is already available for production equipment.

Land

Additional land may have to be purchased in order to comply with BAT/NSPS. This cost is difficult to estimate on a general basis since the information received during the mine visits indicated that the cost can vary from a few hundred dollars to $40,000 per acre. If additional land is required, land costs must be added to the capital cost obtained from the treatment level system curves. The amount of land needed for proposed BAT alternatives is presented on an individual equipment basis for each level of treatment suggested (1). A value of $4,000 per acre is assumed to represent a reasonable cost and is recommended for use unless a different value is known for a particular site.

Equipment

The equipment costs included in this subsection are for polymer addition equipment, pump stations, mixing tanks, clarifiers, gravity filters, and water storage tanks. This encompasses

Table VIII-3

COST OF OVERHEAD ELECTRICAL DISTRIBUTION SYSTEMS

480V System

Distance ft	LOAD - KW					Notes
	100	200	300	400	500	
250	$1500	$1900	$2100	$2500	$3100	
500	$3200	$4900	$5500	$6700	*	*Voltage drop excessive

4.16 KV System

Distance ft	LOAD - KW					Notes
	100	200	300	400	500	
1000	$19,000	$19,000	$20,000	$23,000	$23,000	Power center costs included
1500	$20,400	$20,400	$21,400	$25,000	$25,000	" "
2000	$22,000	$22,000	$23,000	$26,600	$25,600	" "
2500	$23,500	$23,500	$25,300	$29,600	$29,600	" "
3000	$25,000	$25,000	$26,000	$31,500	$31,500	" "
3500	$26,600	$27,700	$28,700	$36,300	$36,300	" "
4000	$28,000	$29,400	$32,400	$38,600	$38,600	" "
4500	$29,800	$31,200	$34,400	$41,000	$41,000	" "
5000	$31,300	$32,900	$36,400	$49,700	$49,700	" "

Reference (2)

Table VIII-4

CAPITAL COSTS FOR DIESEL GENERATOR SETS*

Generator Type	Power Requirement (Kw)	Cost (1000$)
Air-Cooled	10	11
Air-Cooled	30	16
Radiator-Cooled	55	20
Radiator-Cooled	100	24
Radiator-Cooled	150	30

Reference (4)

equipment required for all three treatment levels. Cost estimates for installation, engineering, administration, and contingencies are also included.

Polymer Addition Equipment. Capital costs of polymer addition equipment are relatively insensitive to mine drainage flow rates according to vendor price quotations. Below 750,000 gpd the installed capital cost was estimated at $30,000 and above 750,000 gpd the cost estimate was $40,000. These costs include a mixing tank, feed pump, transfer pump, storage tank, an enclosure, and an electric heater. Costs for the enclosure and heater were additional to those given by the vendors of the polymer equipment. The costs for these two items were estimated at $10,000 for the enclosure and $6,000 for the heater.

Pump Stations. Installed capital costs for pump stations include a 3/8 inch steel structure, pumps and motors, piping, valves, fittings, structural steel (stairwells, ladders, ancillary equipment), electrical equipment and instrumentation. Two pumps were assumed for all flow rates up to 3.0 mgd; above this flow rate three pumps were used.

Mixing Tanks. The cost for the mixing tanks used in level 3 includes three steel tanks and skids, three mixers, nine slide gates, structural steel, aeration systems (blowers and piping), electrical equipment, and instrumentation.

Flocculator-Clarifiers. A flocculator-clarifier composed of a steel tank (1/4 inch thick) in concrete base, the internal flocculation and sludge scraping mechanisms, structural steel, slide gates, sludge pumps and motors, electrical equipment and instrumentation.

Gravity Granular Media Filters. The equipment included with gravity filters is composed of a concrete pad, a backwash water storage tank, piping connections, filter cells, media, underdrain system, electrical equipment and instrumentation. The filters were sized based on a flux rate of 10 gpm/ft^2.

Installation. Installation is defined here to include all services, activities, and materials required to implement the described wastewater treatment systems. Many factors affect the magnitude of this cost including wage rates, in-house or contracted construction work and site dependent conditions. The installation costs are included in capital cost estimates presented in this section.

Engineering, Administration and Contingencies. The costs associated with taxes, insurance, engineering, administration, and contingencies are computed as 25 percent of the installed cost of facilities and equipment.

GENERAL ASSUMPTIONS UNDERLYING ANNUAL COSTS FOR ALL SUBCATEGORIES

The annual costs computed for each of the treatment systems suggested for BAT are categorized as follows:

Amortization

Operation and Maintenance

- Labor
- Materials and Supplies
- Chemicals

Energy

Amortization

The annual depreciation and capital costs are computed based on using the capital recovery factor:

$$AC = (II)(CRF)$$

where

AC = annual cost

II = initial investment

CRF = capital recovery factor = $(r)(r+1)^n/((1+r)^n-1)$

r = annual interest rate

n = useful life in years.

An interest rate of 10 percent was used in all cases. The expected life differs for civil construction work and mechanical and electrical equipment items and their installation, i.e., the expected life for civil construction work is 30 years and 10 years for installed mechanical and electrical equipment. No residual or salvage value is assumed. Based on these assumptions, the general multipliers (AC/II) compute as follows:

$$CRF_{(\text{civil})_{30}} = 0.10608$$

$$CRF_{(\text{mech. \& elec.})_{10}} = 0.16275$$

Operation and Maintenance

General. Operating time of the systems costed is assumed to be for 24 hours per day, 365 days per year.

Operating and Maintenance Personnel. Personnel costs are based on an annual rate of $28,000.

Maintenance Materials. The materials necessary for performing yearly maintenance activities are estimated at three percent of the capital cost of the facilities including the contingency item.

Chemicals. The chemicals costed for use in any of the levels of treatment are polymer and lime. The polymer cost is estimated at $2.00 per pound, lime estimated at $65/ton. Yearly costs will vary according to the dosage level used in the treatment system. A polymer dosage rate of two ppm was selected for computing annual polymer costs in each applicable system.

Power Costs. Electricity costs are based on auxiliary power requirements in terms of kilowatts and 8,760 hours per year of operation. The cost per kilowatt hour is estimated at $0.03 (2).

SLUDGE HANDLING AND ASSOCIATED COSTS

The sludge produced in the treatment of mine drainage, preparation plant effluent and pond sedimentation can be handled by various methods. Three methods which may be used and are considered in this report are: sludge lagoons, trucking of dewatered sludge to disposal site and trucking of undewatered sludge to disposal site.

Sludge Lagoons

The sludge lagoon would require construction of a lagoon and pumping the sludge from the treatment facility to the lagoon. Available data for lime neutralization indicates that sludge production is about 10 percent by volume of the incoming flow (solids concentration of two percent) (1). This sludge would compact in a lagoon to 10 percent solids which equates to three percent by volume of the incoming flow treated. To arrive at a cost it is assumed that the sludge storage requirements would be for an estimated 10 year life of the mine. The cost curves for capital and yearly cost for the sludge lagooning approach are shown in Figure VIII-38.

Haulage of Dewatered Sludge

The method of dewatering sludge considered here consists of pumping the sludge to a thickener. The thickened sludge is then dewatered by vacuum filters before hauling to disposal. It is assumed that this system will increase the solids loading in the sludge to about 25 percent. The cost curves for capital and yearly costs, as well as energy requirements for this dewatering, are shown in Figure VIII-39. The estimated cost for hauling

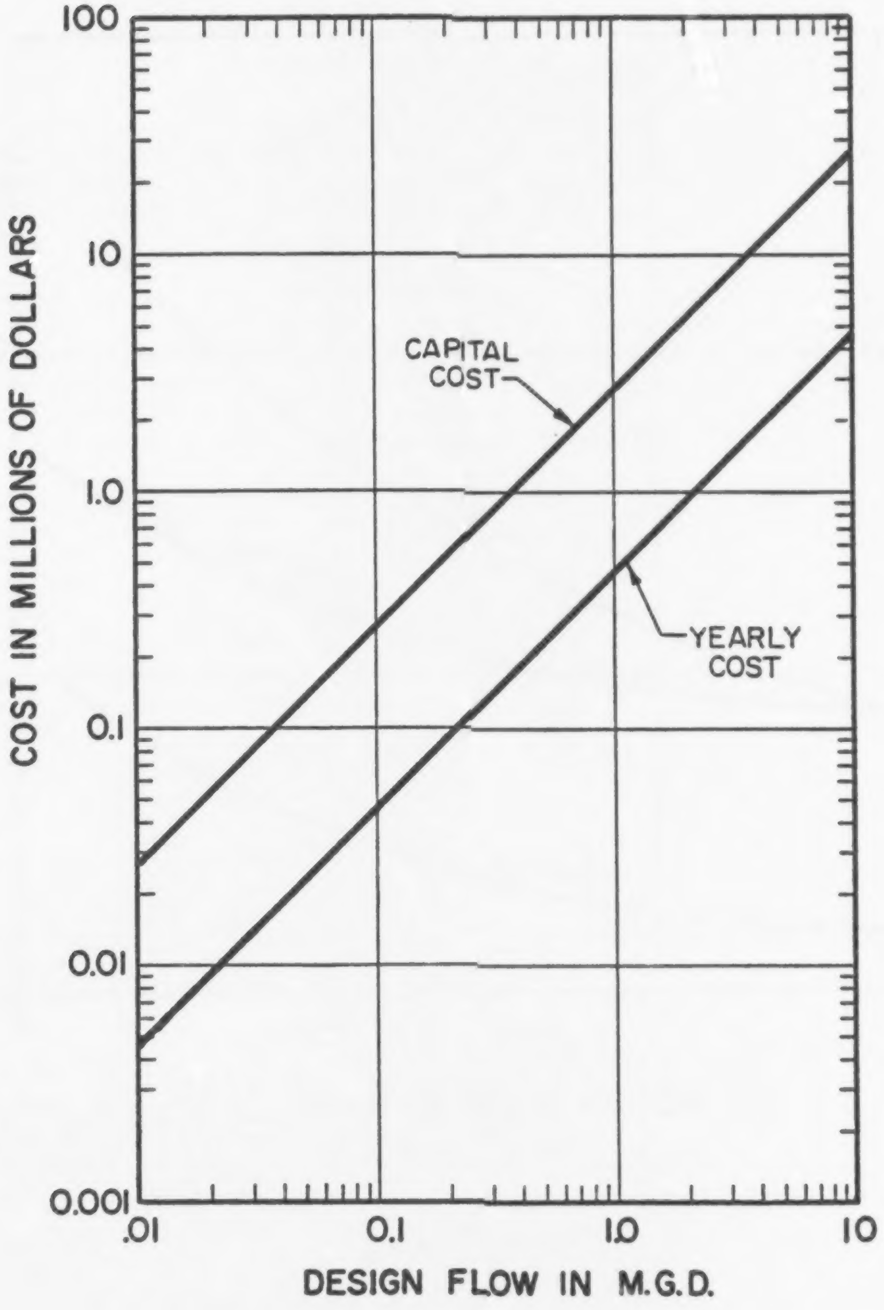


Figure VIII-38

MINE DRAINAGE TREATMENT
SLUDGE LAGOON VERSUS DESIGN FLOW

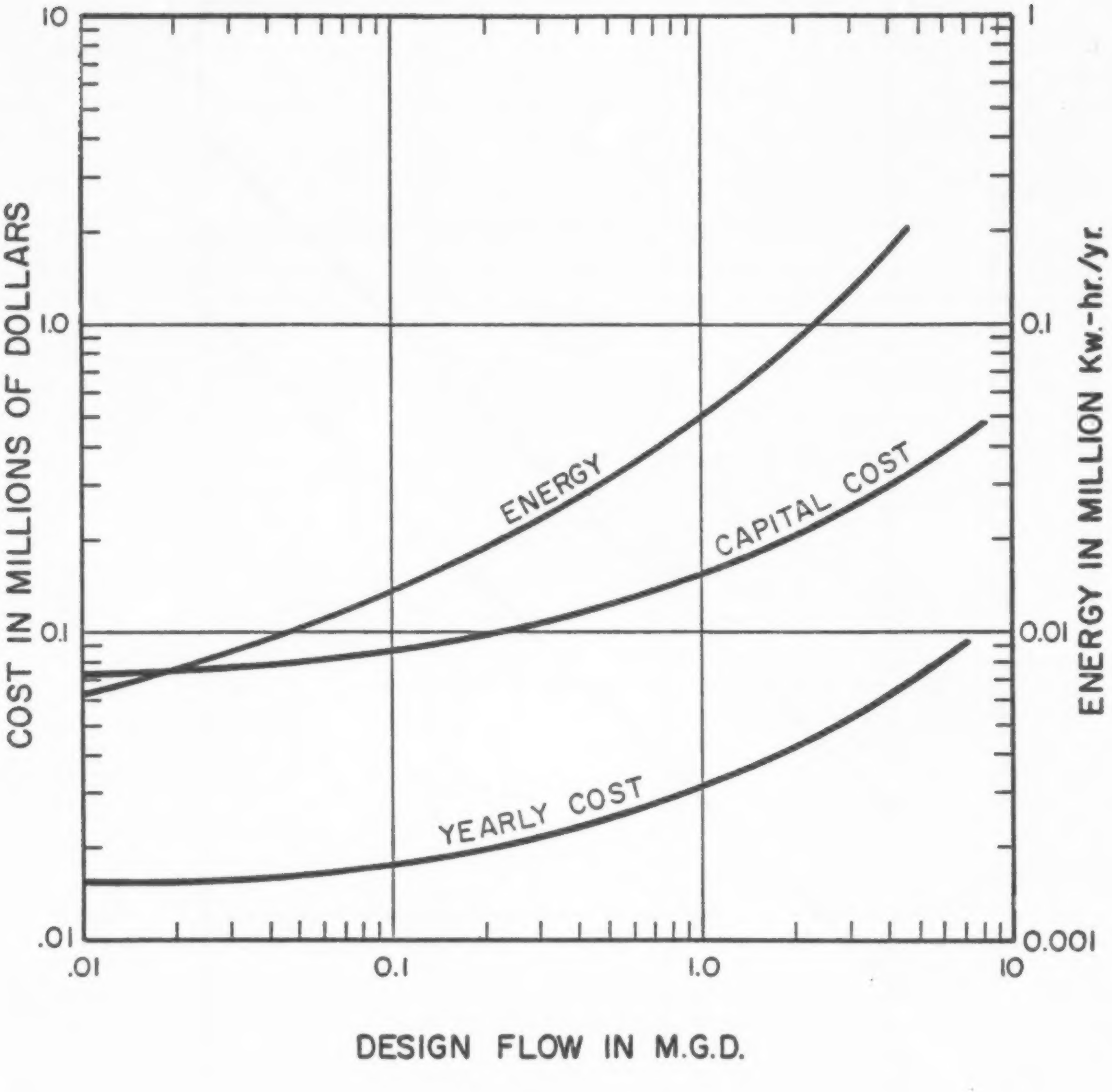


Figure VIII-39

MINE DRAINAGE TREATMENT
SLUDGE DEWATERING VERSUS DESIGN FLOW
COST AND ENERGY CURVES

dewatered sludge to disposal sites, based on a one round trip mile, is presented in Figure VIII-40. To maintain a uniform cost basis, this curve is a plot of design flow in mgd versus cost in thousands of dollars.

Haulage of Undewatered Sludge

The final sludge handling approach is to haul the sludge to disposal sites without dewatering. This involved pumping the sludge at about two percent solids to a tank truck and then hauling to a disposal site where it is lagooned or pumped into a bore hole. The trucking cost for hauling this sludge, based on a round trip mile, is also presented in Figure VIII-40. Assumptions and cost criteria for sludge handling are based on information provided in reference (2).

To calculate the cost of land, Figure VIII-41 presents the sludge lagoon area required versus mine drainage flow rates.

REGIONAL SPECIFICITY FOR COSTS

Variations in capital and annualized costs are dependent on the region in which the treatment facility is located. These differences are due to such factors as soil type, precipitation, topography, and vegetation. Cost multipliers have been prepared to reflect these cost differences and are presented in Table VIII-6 in the column entitled "Basic Capital Cost Multiplier." The development of these multipliers is presented in reference (5).

Before using these multipliers for a particular region, the extent to which certain costs have already been absorbed in establishing BPT facilities should be determined; this may require a certain degree of downward multiplier adjustment in the cost. Items which affect the accuracy of these basic multipliers are previously built-in access roads, clearing and grubbing, etc.

The development of the Capital Cost Multiplier Adjusted to Civil Works was based on the premise that the multiplier is only applicable to that portion of the capital cost which is associated with excavation, backfilling, and concrete placement. The assumed contribution which these items provided in the overall construction investment is 40 percent. Thus, the basic multipliers are adjusted to 40 percent of their original value (5). Table VIII-6 also presents the formula which demonstrates the application of the adjusted capital cost multiplier to yearly costs. Regional cost multipliers for yearly cost would apply only to that portion of the yearly cost associated with the civil works part of the facilities, such as the civil works portion of the amortization and associated charges.

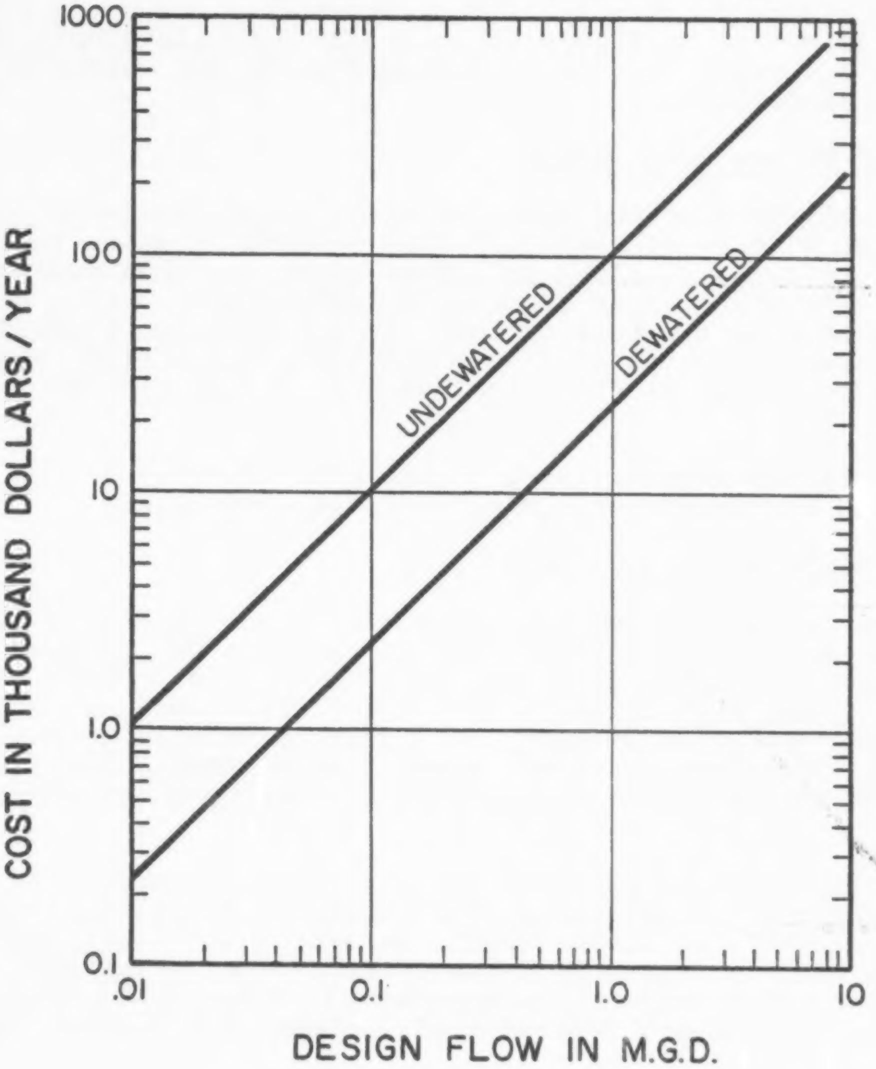


Figure VIII-40

YEARLY COST OF ONE ROUND TRIP MILE
OF SLUDGE HAULING VERSUS DESIGN FLOW
MINE DRAINAGE TREATMENT

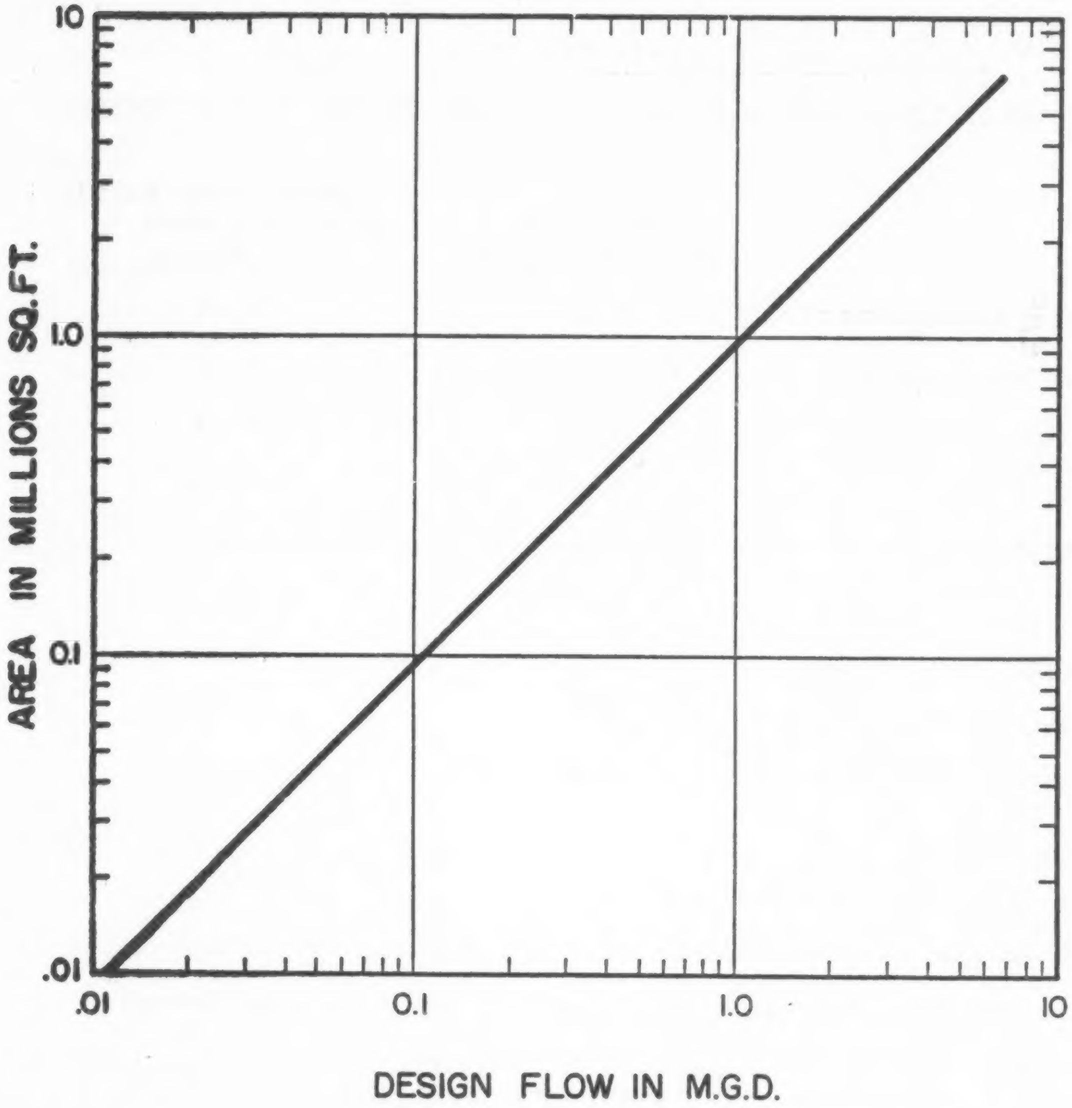


Figure VIII-41

SLUDGE LAGOON - AREA REQUIRED VERSUS DESIGN FLOW
MINE DRAINAGE TREATMENT

Table VIII-5

COST MULTIPLIERS FOR COAL MINING REGIONS IN THE UNITED STATES

Region	Basic Capital Cost Multiplier	Capital Cost Multiplier Adjusted to Civil Works
Northern Appalachia	1.8	1.32
Central Appalachia	1.8	1.32
South Appalachia	1.7	1.28
Midwest	1.3	1.12
Central West	1.2	1.08
Gulf	1.0	1.0
Northern Great Plains	1.0	1.0
Rockies	1.9	1.36
Southwest	1.65	1.26

NOTES:

To obtain the adjusted yearly cost for a region where the capital cost multiplier is greater than one use the following formula:

$$\begin{array}{l} \text{Adjusted} \\ \text{Yearly} \\ \text{Cost} \end{array} = \begin{array}{l} \text{Yearly} \\ \text{Cost from} \\ \text{Curve} \end{array} - \begin{array}{l} \text{Capital} \\ \text{Recovery} \\ \text{Factor} \end{array} \times \begin{array}{l} \text{Yearly} \\ \text{Cost from} \\ \text{Curve} \end{array} \times 1 - \begin{array}{l} \text{Capital} \\ \text{Cost} \\ \text{Multiplier} \end{array}$$

Reference (5)

Examples of regionally specific cost determination procedures are provided in the cost manual (1).

NON-WATER QUALITY ASPECTS

The effects of the candidate technologies on air pollution, solid waste generation, and energy requirements have been considered. The latter aspect has been addressed in earlier subsections, and will not be repeated.

Air Pollution

Imposition of regulations based on any of the candidate technologies in any subcategory will not create any additional air pollution.

Solid Waste Generation

The neutralization and aeration of acid mine drainage results in a suspension of ferric hydroxide, other metal hydroxides, and unreacted reagents (lime) in an aqueous solution of salts composed largely of sulfates. This suspended matter must be removed before the water is discharged. Also, alkaline drainage contains sediment which requires removal.

Many preparation plants in the United States use water to assist in the sizing, separation, and cleaning of run-of-mine coal. The waste slurry discharged from the plant is often high in suspended coal fines that require reduction or removal prior to recycle or discharge. Also, coal preparation facilities generate a solid or semisolid refuse of material rejected from the cleaned coal. Ash, clays, and other materials make up this refuse, which is conveyed as a slurry to a refuse pile, or disposed of in some other manner.

The creation of these sludges result from application of the BPT requirement. Additional sludge generation resulting from the candidate technologies are discussed in the following paragraphs.

Flocculant Addition and Granular Media Filtration

For mine drainage or preparation plant wastewaters, the application of these technologies would result in additional sludge production of a composition similar to sludge generated by BPT requirements. However, the amount of this extra solid waste would be minimal in comparison with quantities produced by compliance with BPT. For instance, in the acid drainage subcategory, the average TSS removal (which makes up a substantial portion of the solid waste) at a typical mine by application of BPT is 1,310 pounds per day. Installation of flocculant addition equipment would result in an additional estimated removal of 40 pounds per day, or a little over three percent of the BPT sludge production. For application of filtration technology, additional sludge production would be approximately 80 pounds per day, or less than 6.5 percent of the sludge produced under the BPT requirement.

Total Recycle Option-Preparation Plants

The BAT option is being considered only for preparation plant wastewaters (distinct from preparation plant associated area wastewater). As in the previous case, the additional sludge resulting from selection of the zero discharge option would be minimal. Again, using a typical facility, 370,000 pounds per day are removed from the wastewater by application of settling (BPT) technology (this figure does not include the small amounts of any gypsum or other "spectator" solids that might settle). Installation of facilities to achieve total recycle would remove an additional 140 pounds per day from waters discharged to the environment.

Settling - Reclamation Areas

The Agency is proposing requirements for areas under reclamation and for sites where mining has ceased. Because these requirements are based on a technology whose installation is already required by another federal agency (the Office of Surface Mining), there will be no incremental non-water quality impacts resulting from the EPA proposal. Because the composition of the settled material does not include toxic metals, the environmental impacts of solid waste disposal in this subcategory are projected to be minimal.

SECTION IX

AMENDMENTS TO BPT

Three subcategories were established as the basis for promulgation of effluent limitations based on application of the best practicable technology currently available. These subcategories include coal preparation plants and associated areas, alkaline mine drainage, and acid mine drainage. A fourth subcategory was also established for reclamation areas. A western mines (those located west of the 100th meridian) subcategory was also proposed. The catastrophic precipitation event exemption was investigated for any necessary modifications. Extension of the period of applicability for certain effluent limitations for post mining discharges from deep mines was also considered.

WESTERN MINES

As discussed in Section V, western mines are not subcategorized separately.

POST MINING DISCHARGES

Reclamation Areas

This subcategory was established during the NSPS rulemaking, but the Agency deferred publication of any limitations until further data could be gathered and analyzed. As discussed in Sections V and VII, additional data have been collected that support the establishment of this subcategory. Pollutants to be regulated include settleable solids and pH.

The Agency has concluded that the following limitations shall apply to the reclamation areas subcategory for mining of coal of all ranks including, but not limited to, lignite, bituminous, and anthracite:

	Effluent Limitations	
Effluent Characteristic	Maximum for Any One Day	30 Day Average
Settleable Solids	0.5 ml/l	----
pH	within the range 6.0 to 9.0 at all times	----

Underground Mine Discharges

EPA has evaluated the length of time that effluent limitations should remain in effect after a mine has closed and reclamation of the area initiated. This is discussed in Sections V and VII. In the case of deep mines, the pertinent effluent limitations will remain effective until the applicable reclamation bond has been released, ensuring that pollution abatement will continue until effective sealing and reclamation has been completed. These limitations are tabulated under the applicable mine drainage subsection.

CATASTROPHIC PRECIPITATION EVENT EXEMPTION

A further revision to BPT, in reference to sedimentation ponds, deals with catastrophic precipitation events (CPE). Studies indicate that even when sedimentation pond size is in compliance with certain design criteria (i.e., if the pond is designed to contain the amount of water resulting from a 10-year, 24-hour storm), during certain rainfall events less than the 10-year, 24-hour event, TSS concentrations remain higher than the established limitations. This is the case even for optimally designed and operated ponds. However, as discussed in Section VII, settleable solids are consistently removed during various rainfall events.

The Agency will adopt the following exemption provision:

Any overflow, increase in volume of a discharge or discharge from a bypass system caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt resulting in equivalent volume) shall be subject to the following alternate limitations:

	Effluent Limitations	
Effluent Characteristic	Maximum for Any One Day	30 Day Average
Settleable Solids	0.5 ml/l	----
pH	within the range 6.0 to 9.0 at all times	----

Any overflow, increase in volume of a discharge or discharge from a by-pass system caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt resulting in equivalent volume) shall be subject to the following alternate limitations:

Effluent Characteristic	Effluent Limitations Maximum for Any One Day	 30 Day Average
pH	within the range 6.0 to 9.0 at all times	----

These alternate limitations shall be available only if the facility is designed, constructed, operated, and maintained to contain at a minimum the volume of water which would drain into the facility during a 10-year, 24-hour precipitation event (or snowmelt of equivalent volume). The treatment facility must also be designed, constructed, operated, and maintained to consistently achieve the applicable effluent limitations during periods of no precipitation (or snowmelt) and to ensure that the pH in the final effluent remains in the range of 6.0 to 9.0 during the precipitation event (or snowmelt). The operator shall have the burden of demonstrating to the appropriate authority that the prerequisites for the alternate limitations have been met.

SECTION X

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BAT)

The factors considered in assessing best available technology economically achievable (BAT) include the age of equipment and facilities involved, the process employed, process changes, non-water quality environmental impacts (including energy requirements) and the costs of application of such technology (Section 304(b)(2)(B)). In general, the BAT technology level represents, at a minimum, the best economically achievable performance of plants of various ages, sizes, processes, or other shared characteristics. Where existing performance is uniformly inadequate BAT may be transferred from a different subcategory or category. BAT may include process changes or internal controls, even when not common industry practice.

EPA proposed BAT limitations for two subcategories (coal preparation plants and preparation plant associated areas) of the coal mining industry on 13 May 1976 (41 FR 19841). These subcategories were later combined in the modified proposal for BAT requirements published in the 26 April 1977 Federal Register (42 FR 21380). Also on 13 May 1976, the Agency proposed BAT standards for the alkaline and acid mine drainage subcategories based on the application of granular media filtration. These proposed standards were unchanged in the 26 April publication, pending toxic pollutant data collection and analysis in keeping with the Settlement Agreement and the Clean Water Act.

The statutory assessment of BAT "considers" costs, but does not require a balancing of costs against effluent reduction benefits. In developing the proposed BAT, however, EPA has given substantial weight to the reasonableness of costs. The Agency has considered the volume and nature of discharges, the volume and nature of discharges expected after application of BAT, the general environmental effects of the pollutants, and the costs and economic impacts of the required pollution control levels.

Despite this expanded consideration of costs, the primary determinant of BAT remains effluent reduction capability. Effluent limitations in this industry are expressed as concentrations (i.e., mass per unit volume, most often milligrams per liter--mg/l). Mass limitations cannot be written because wastewater flow cannot be correlated with coal production. This stems from the fact that, although little process water is employed in coal extraction, large volumes of water still require treatment because of infiltration from precipitation and runoff through the active mining area as well as groundwater seepage from breached aquifers. Thus a particular mine may have large volumes of water to treat that are essentially independent of the coal production capacity of the mine. This situation is also found in the coal

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preparation segment. Although process water used for coal cleaning can be correlated with production, wastewater flows are impossible to predict due to varying amounts of surface runoff from preparation plant associated areas such as coal stockpiles.

The Agency considered a number of options for regulation of existing sources subject to the BAT requirement and new sources subject to the NSPS requirement. The BAT limitations options are detailed below. New source options are discussed in Section XII.

BAT OPTIONS CONSIDERED

OPTION ONE - Require effluent limitations equivalent to those promulgated under BPT. For acid drainage mines and coal preparation plants and associated areas the limitations are based on the application of neutralization, aeration, and settling technology. For alkaline mines and areas under reclamation, limitations are based on application of settling technology.

The basic elements of the storm exemption published on 28 December 1979 (44 FR 76788) are adopted with a number of modifications.

First, settleable solids and pH limitations will apply during the exemption period.

Second, the exemption currently requires operators to "contain or treat" the runoff from a design storm to successfully claim the exemption. This language has caused unnecessary confusion, since some have misinterpreted the phrase "to treat." This language was included to cover those few coal mines where chemical coagulants are added as part of the treatment system. The Agency did not intend to imply that treatment of storm runoff to a certain level was required. To eliminate this confusion, EPA has removed the phrase "to treat" from the exemption language, but includes as a prerequisite for the exemption a demonstration that the treatment facility can consistently treat to the "dry weather" limitations during periods of no precipitation.

Third, discharges from underground mines will no longer be exempt from effluent limitations, regardless of storm size. Precipitation does not significantly affect the mechanism of underground mining discharges, and thus no relief from effluent limitations is necessary. Techniques for minimizing or preventing infiltration in underground mines are presented later in this section.

The settleable solids and pH limitations that apply during the exemption period are based on application of settling technology and were developed from data collected by the Agency during various types of storm events. Pollutant coverage would be extended to include post mining discharges from both deep and surface mines. These limitations would apply through release of the applicable reclamation bond.

Additional costs borne by the operator by selection of this option would be restricted to operation and maintenance costs of pollution control equipment to comply with the extended pollutant coverage provisions and for monitoring during the storm exemption period. These costs are minimal.

OPTION TWO - Require effluent limitations based on flocculant addition technology. A treatability study commissioned by the Agency has shown that when toxic metals were spiked into the untreated wastewater, substantial reduction of these pollutants was also achieved along with suspended solids. Additional toxic metal removals for BPT-treated water without spiking were highly variable due to the low influent levels of these metals.

Costs for installation and operation of this technology would range from $30,000 to $40,000 per outfall for capital costs and from $.042/1,000 gallons treated to $.41/1,000 gallons treated for annual costs.* The cost of implementating this option at preparation plants and associated areas for the entire U.S. is 50.0 million dollars (capital) and 25.1 million dollars (annual) for this subcategory.

The extended pollutant coverage and the modified storm exemption discussed under BAT Option One would also apply here.

OPTION THREE - Require effluent limitations based on the application of granular media filtration technology. Two acid drainage treatment plants were studied for evaluation of this technology. They consisted of BPT treatment (neutralization, aeration, and settling) of acid mine drainage followed by a dual-media filter. Toxic metal reductions are not quantified because influent concentrations of toxic metals to the filter were very low, i.e., the neutralization and settling processes effectively removed the priority metals contained in the raw wastewater.

Capital costs for this technology range from $150,000 for a design flow of 100,000 gpd to $900,000 for a design flow of 8,000,000 gpd. Annual costs for filtration range from $.51/1,000 gallons treated for the 100,000 gpd facility to $.055/1,000 gallons treated for the 8 mgd facility. No capital and annual costs were estimated for implementation of this option specifically for preparation plants and associated areas.

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*Note: The lower cost was calculated assuming a two mg/l dosage rate and a 4.5 mgd facility; the higher cost was calculated assuming a two mg/l dosage rate and a 0.1 mgd facility.

The extended pollutant coverage and modified storm exemption discussed in BAT Option One would apply if this option were selected.

OPTION FOUR - Require no discharge of pollutants from existing source preparation plants, with one of the other options selected for the mine drainage subcategories. Associated area drainage would be segregated from preparation plant wastewaters for separate treatment. Total recycle would be necessary, with ditching or diking installed around the slurry pond to divert storm and other surface runoff. Makeup water would be provided from an independent source. Associated area drainage would, if required, be neutralized and settled in a separately constructed facility. The extended pollutant coverage and storm exemption discussed in BAT Option One would apply to the associated area drainage treatment system only.

Total industry capital costs for implementation of this option are estimated to total 291.2 million dollars. Annual costs are estimated at 52.6 million dollars.

BAT SELECTION AND DECISION CRITERIA

EPA has selected Option One as the basis for proposed effluent limitations. Although some small amount of additional metals and suspended solids removal was provided by Options Two and Three, the costs associated with installation and operation of these technologies are too high to warrant such removal. Further, additional removals at these levels are difficult to accurately quantify due to the magnitude of analytical error associated with their measurement.

Options Two and Three provided only small incremental toxic metal removals and in some cases exhibited virtually no additional removal at all. Suspended solids removals were quantifiable; however, these technologies are subject to the BCT "cost reasonableness" test. As discussed in Section XI, the Agency has concluded that the BCT evaluation is not applicable to effluents from the coal mine industry. Thus, lower BAT limitations based on these technologies could not be justified.

Option Four for existing preparation plants was not selected, based upon the high retrofit expenditures. In the Agency's judgment, the costs of retrofitting for zero discharge are significantly higher at minimal environmental improvement than the costs and benefits of the selected option. As noted in Section XII, New Source Performance Standards (NSPS), this option was selected for new source preparation plants.

The BAT effluent limitations guidelines for the coal mining category are summarized in Table X-1.

Table X-1

EFFLUENT LIMITATIONS BASED ON BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BAT)

	Effluent Limitations	
Subcategory and Effluent Characteristics	Maximum for any one day	Average of daily values for 30 consecutive days shall not exceed
Acid Mine Drainage:		
Fe (total)	7.0	3.5
Mn (total)	4.0	2.0
TSS	70	35
pH	within the range 6.0 to 9.0 at all times	---
Alkaline Mine Drainage:		
Fe (total)	7.0	3.5
TSS	70	35
pH	within the range 6.0 to 9.0 at all times	---
Preparation Plants and Associated Areas:		
Fe (total)	7.0	3.5
Mn (total)	4.0	2.0
TSS	70	35
pH	within the range 6.0 to 9.0 at all times	---
POST MINING DISCHARGES		
Areas Under Reclamation		
Settleable Solids	0.5 ml/1	---
pH	within the range 6.0 to 9.0 at all times	---
Underground Mine Discharges	Effluent limitations that apply from appropriate active mine drainage subcategory	

BEST MANAGEMENT PRACTICES (WATER MANAGEMENT)

Section 304(e) of the Clean Water Act (33 U.S.C. 1251) authorizes the Administrator of EPA to promulgate Best Management Practices (BMPs) for each class or subcategory of both point and nonpoint sources of pollution. Under the Surface Mining Control and Reclamation Act of 1977 (SMCRA) (Public Law 95-87), OSM was assigned responsibility for the development of a comprehensive program to ensure environmental protection and land reclamation of surface coal mining operations. Water handling practices can include the application of various mining, aquifer and erosion control techniques to prevent or minimize adverse environmental effects. The purpose of these techniques is to effect a reduction in effluent water volumes and/or an improvement in effluent quality, thereby reducing wastewater treatment and its associated costs. The following paragraphs discuss water management practices available to operators and permit authorities to reduce wastewater quantity.

For both surface mining and the surface effects of underground mining, OSM has promulgated specific regulations governing water management associated with mining and reclamation operations (44 FR 15143-15178). A number of these standards have been remanded as a result of litigation; therefore, OSM is now in the process of a new rulemaking.

Underground Mines

Surface or groundwater may enter underground mines from above, below, or laterally through adjacent rock strata. Faults, joints, and roof fractures are common sites of water entrance into abandoned underground mines. Water may also enter mines through exploration drill holes or through boreholes that supply power and air to underground equipment. Surface water can drain into underground mines from surface mines or as a result of inadequate stream diversion practices. Flooding or seepage from adjacent abandoned or inactive underground mines is often a significant source of water infiltration. Factors that can affect the quantity of water entering a deep mine are: the depth of the mine, the source of the drainage, the location of water bearing strata, and groundwater flow patterns. Investigations of the quantity of water entering underground coal mines have found the average rate of infiltration to vary between 6,260 and 10,280 liters per hectare per day (670 to 1,100 gal/acre/day). These rates may be exceeded if catastrophic flooding of a mine occurs from adjacent or overlying abandoned drifts (1).

Various infiltration control practices are required in order to comply with OSM regulations restricting the discharge of water into underground mines (44 FR 15269 sec. 817.55). OSM requirements endorsed by EPA include:

1. Borehole sealing and casing
2. Mine sealing
3. Regrading and revegetation of surface facilities, and
4. Surface water diversion

Borehole Sealing

Underground mines are commonly intercepted by boreholes extending from the ground surface. These holes are sometimes drilled during mineral exploration, but may also be utilized for supplying power or air to underground equipment or for discharge water pumped from active sections. Upon abandonment of an underground mine, these boreholes may collect and transport surface and groundwater into the mine.

These vertical, or nearly vertical, boreholes can be successfully sealed from below in an active underground mine. The sealing can also be achieved by placing packers and injecting a cement grout. Often abandoned holes will be blocked with debris and will require cleaning prior to sealing. The packers should be placed below aquifers overlying the mine to prevent entry of sub-surface waters, but should be well above the roof to prevent damage to the seal from roof collapse.

A borehole may also be sealed by filling the hole with rock until the mine void directly below the hole is filled to the roof. Successive layers of increasingly smaller stone should be placed above the rock. A clay and/or concrete plug is then placed in the borehole. The remainder of the borehole may be filled with rock or capped.

Mine Sealing

Several techniques contained in the OSM program prevent post-mining formation of acid mine drainage. One of these techniques is mine sealing. Mine sealing is defined as the closure of mine entries, drifts, slopes, shafts, subsidence holes, fractures, and other openings in underground mines with clay, earth, rock, timber, concrete, fly ash, grout, and other materials. The purpose of mine sealing is to control or abate the discharge of mine drainage from active and abandoned mines.

Mine seals have been classified into three types based on method of construction and function. The three seal types are:

1. Dry Seal--The dry seal is constructed by placing suitable material in mine openings to prevent the entrance of air and water into the mine. This seal can be applied to openings where there is little or no water flow from within the mine and little danger of a hydrostatic head developing.

2. Air Seal--An air seal prevents the entrance of air into a mine while allowing the normal mine discharge to flow through the seal. This seal is constructed with a water trap similar to the traps in sinks and drains.

3. Hydraulic Seal--Construction of a hydraulic seal involves placing a plug in a mine opening that is discharging water. The plug prevents discharge after the mine is flooded. Flooding excludes air from the mine and retards the oxidation of sulfide minerals. However, the possibility of the failure of mine seals or outcrop barriers increases with time as the sealed mine workings gradually become inundated by groundwater and the hydraulic head increases. Depending upon the rate of groundwater influx and size of the mine area, complete inundation of a sealed mine may take several decades. Consequently, the maximum anticipated hydraulic head on the mine seals may not occur for a long time. In addition, seepage through, or failure of, the coal outcrop barrier or mine seal could occur at any time.

Surface Area Regrading

Water discharging from underground mines often originates as surface water from ungraded, unvegetated strip mine spoils. This commonly occurs in the eastern United States where coal outcrops are often mined by contour stripping techniques. These strip mines can intercept underground workings or have underground mine entries and auger holes located along the highwall. When these openings occur on the updip side of an underground mine, large volumes of surface water may be conveyed to underground workings. Surface mines may collect water and allow it to enter a permeable coal seam. This water can flow along the seam to adjacent underground mines.

The purpose of regrading is to return the disturbed area back to its approximate original contour, with natural drainageways and watersheds.

Various methods of surface regrading have been practiced in the eastern coal fields. The selection of a regrading method will depend upon such factors as: the amount of backfill material available, the degree of pollution control desired, future land use, funds available and topography of the area. Prior to backfilling, impervious materials may be compacted against the highwall and coal seam to prevent the flow of water to adjacent underground mines. Where contour terrace regrading methods are applied, surface runoff is diverted away from the highwall.

Surface Water Diversion

Surface cracks, subsidence areas, ungraded surface mines, and shaft, drift and slope openings often are the source of surface water infiltration into underground mines. Water diversion entails the interception and conveyance of water around these underground mine openings. This procedure controls water infiltration and decreases the volume of mine water discharge.

Ditches, trench drains, flumes, pipes, and dikes are commonly used for surface water diversion. Ditches are often used to divert water around surface mines. Flumes and pipes can be used to carry water across surface cracks and subsidence areas. To ensure effective diversion, the conveyance system must be capable of handling maximum expected flows. Riprap may be required to reduce water velocities in ditch type conveyance systems.

In addition to the above practices required by OSM, permit writers may make use of the following water management practices to assure the control of infiltration into underground mines:

1. Surface or subsurface sealing
2. Channel reconstruction
3. Aquifer interception
4. Subsidence sealing and grading

Surface Sealing

Surface mines that overlie deep mines can collect water in a pit and this water could percolate into the underground facility. To control this, the surface permeability should be reduced which can be accomplished by placement of impervious materials, such as concrete, asphalt, rubber, plastic, latex, or clay on the ground surface. Surface permeability may also be decreased by compaction; however, the degree of success will depend upon soil properties and the compaction equipment utilized.

A seal below the surface would have several advantages over surface seals: it would be less affected by mechanical and chemical actions; land use would not be restricted; and the seal would most likely be located in an area of lower natural permeability. The seal would be formed by injecting an impermeable material into the substrata. Asphalt, cement and gel materials have been used to control water movement below the surface. The effectiveness of various latexes, water soluble polymers, and water soluble inorganics, which hydrate with existing ground materials to form cement like substances, has been demonstrated in laboratory and field tests. However, large scale applications of subsurface sealants to control acid mine drainage have not been demonstrated.

Channel Reconstruction

Vertical fracturing and subsidence of strata overlying underground mines often create openings on the ground surface. Streams flowing across these openings may have a complete or partial loss of flow to the underground workings. During active operations, pumping of this infiltrating water is required. In both active and abandoned underground mines the problem of infiltrating stream flow can be effectively controlled by reconstructing and/or lining the stream channel. The reconstructed channel bottom may be lined with an impervious material to prevent seepage or flow to the underground mine. To ensure complete and effective diversion, the reconstructed channel must be capable of handling peak stream flows.

In instances when stream flow cannot be diverted to a new channel, flow into underground mines can be controlled by plugging the mine openings with clay or other impervious material.

Aquifer Interception

This mine water handling technique utilizes hydrogeologic features of an underground mine in order to help prevent the inflow and contamination of groundwater. Wells are drilled from the land surface through the aquifer to the underground mine. The groundwater may then be drained through the mine zone for discharge into underlying aquifers, or conveyed from the mine through a pipe system.

Subsidence Sealing and Grading

Before or after abandonment of underground mines, fracturing or general subsidence of overlying strata can occur. This fracturing increases the permeability of the strata, and can result in the flow of large volumes of water into a mine. The volume of water that is diverted into an underground mine via fracturing or subsidence depends upon the structure of the overlying rock, and the surface topography and hydrology of the area.

Vertical permeability may be decreased by placing impermeable materials around the subsided area. These materials may be compacted on the surface and graded, or placed in a suitable sealing strata below ground level. Materials which have been successfully utilized for subsidence sealing are rubber, clay, concrete, and cement.

Prevention of Acid Formation

Because sufficient water is almost always present in deep mines to allow acid formation, methods for reducing oxygen availability and contact time are important in preventing this reaction. Reduction of contact time can be accomplished during active operations by pumping water from the mine and maintaining the mine pool at a sufficiently low level. Pumping costs can be quite high, particularly if the water sources are diffuse; therefore, it is also good practice to try and reduce the amount of water flowing into the mine. For inactive or abandoned mines, mine sealing is a viable alternative. This method can eliminate oxygen from entering an underground mine.

Surface Mining

Water handling techniques for surface mines include practices associated with two categories: (1) mining technology, and (2) reclamation technology. Pre-mine planning to institute these practices is very important, as is borne out by the permit procedures required by OSM. The mining and reclamation techniques discussed in this subsection represent source control methods that can contain or prevent pollution formation during active mining.

Mining Methods

Certain mining techniques can help reduce the environmental impacts of coal strip mining. One such technique currently employed by industry and favored by OSM is termed "Modified Block Cut" mining.

This method is basically applicable to moderate slopes (20° or less), low highwalls (60 feet average) and thin seams. It has been applied to mines located in the east. This technique is expected to be feasible in even steeper terrain.

The modified block cut method is a variation of conventional contour strip mining (2). Material from the first cut is often stored in a valley or head of hollow fill. This initial cut is usually three times wider than each succeeding cut in order to accommodate excess spoil as the mining plan progresses. After completion of each cut, a void is created near the highwall to store pollutant-forming materials encountered during mining.

Overburden from the next cut is backfilled into the previous cut simultaneously exposing coal and initiating reclamation. This method offers several advantages:

1. Overburden is handled only once,

2. Most of the spoil is confined to a mined area,

3. Spoil on the downslope is almost completely eliminated thereby reducing the amount of disturbed area,

4. Reclamation is concurrent, and

5. Grading and revegetation areas are reduced.

Figure X-1 illustrates the "Modified Block Cut" method.

Excess Spoil Disposal

According to OSM regulations, spoil not used in returning the land to approximate original contour must be hauled and placed in a designated disposal area. The operator must ensure that leachate and surface runoff from the fill will not harm the surface waters or groundwater and the fill area must be suitable for reclamation. The regulations allow three types of fill design: valley, head-of-hollow, and durable rock.

A valley fill can be described as follows: a structure located in a hollow where the fill material has been hauled and compacted into place with diversion of upstream drainage around the fill. In addition, according to OSM regulations, valley fills must meet rules for subdrainage and filter systems.

Head-of-hollow fills are constructed in a manner similar to valley fills. However, instead of diverting upstream drainage around the fill, a rock-core chimney, constructed from the toe to the head of the fill, passes drainage through a fill core. In addition, head-of-hollow fills must completely fill the disposal site to the approximate elevations of the ridge line (3). Figure X-2 illustrates a head-of-hollow fill.

Durable rock fills represent a third type of valley fill but can be utilized only if the amount of durable rock (i.e., rocks which do not slake in water) is 80 percent of the total fill volume. Spoil material is dumped over a berm located at the head of the fill. The rock material forms a natural blanket drainway across the bottom of the fill. A drainage system is required but the regulations leave design open to the operator (3).

Reclamation

Proper reclamation techniques play a vital role in overall environmental quality control for any mining operation. Reclamation is considered an integral part of the overall mining plan. According to SMCRA, as contemporaneously as practicable with operations, all disturbed land shall be reclaimed to a condition equal to or exceeding any previous use which such lands were capable of supporting immediately prior to any exploration or mining function. Reclamation techniques center basically on regrading and revegetation.

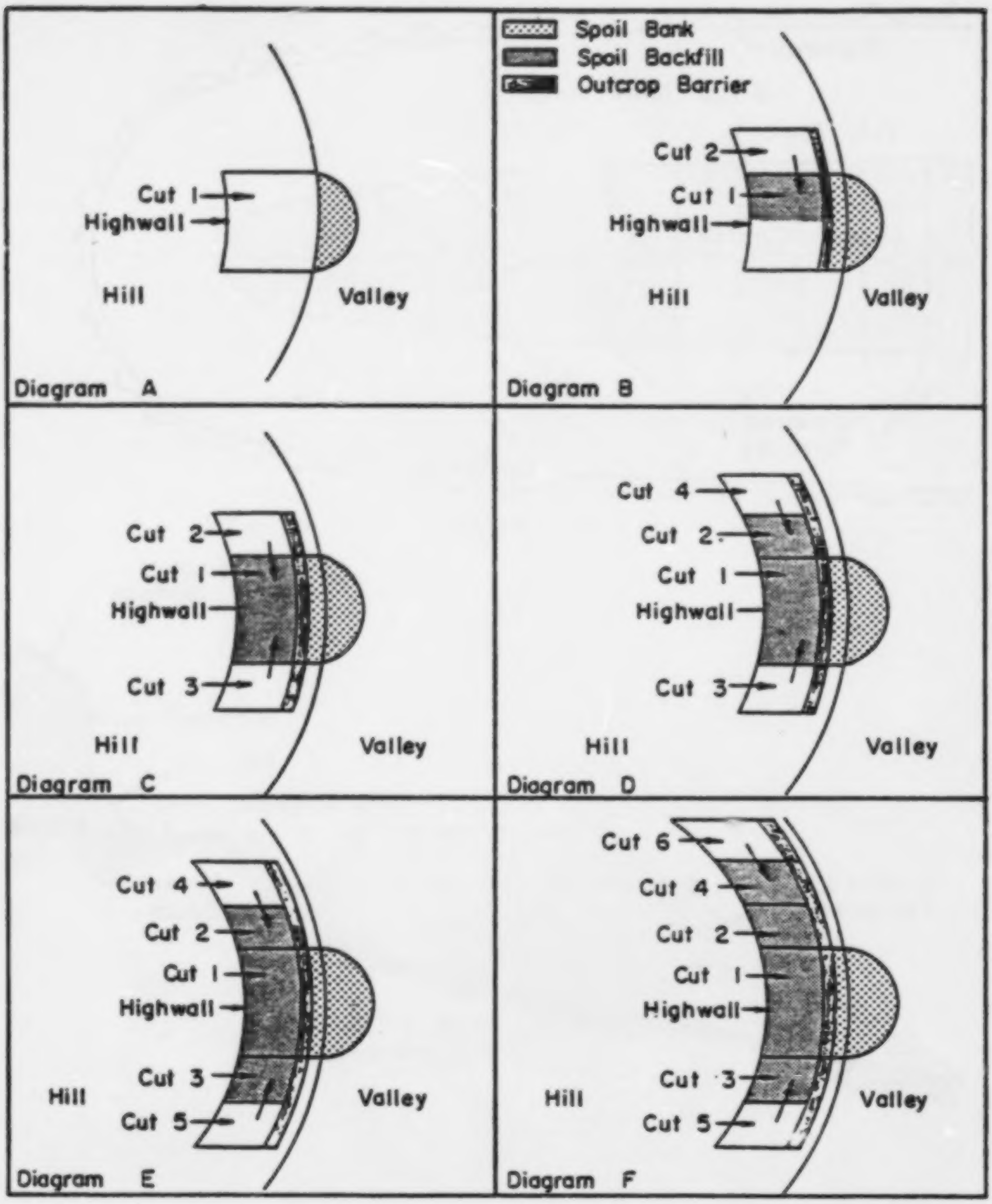
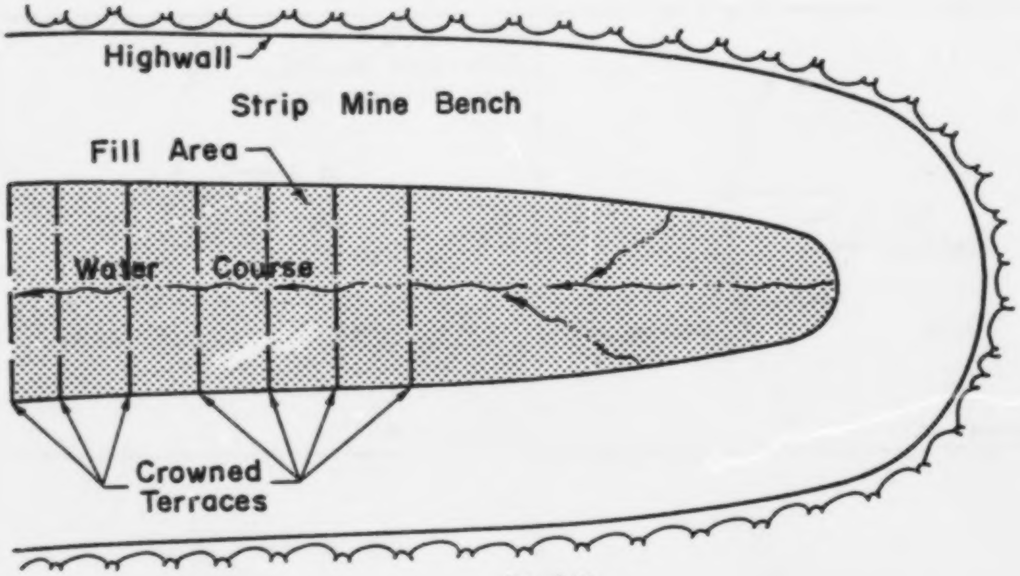

Spoil Bank
Spoil Backfill
Outcrop Barrier
Cut 1
Highwall
Hill
Valley
Diagram A
Cut 2
Cut 1
Highwall
Hill
Valley
Diagram B
Cut 2
Cut 1
Highwall
Cut 3
Hill
Valley
Diagram C
Cut 4
Cut 2
Cut 1
Highwall
Cut 3
Hill
Valley
Diagram D
Cut 4
Cut 2
Cut 1
Highwall
Cut 3
Hill
Cut 5
Valley
Diagram E
Cut 6
Cut 4
Cut 2
Cut 1
Highwall
Cut 3
Hill
Cut 5
Valley
Diagram F

Figure X-1

MODIFIED BLOCK CUT

Source: (1)


Highwall
Strip Mine Bench
Fill Area
Water Course
Crowned Terraces

PLAN

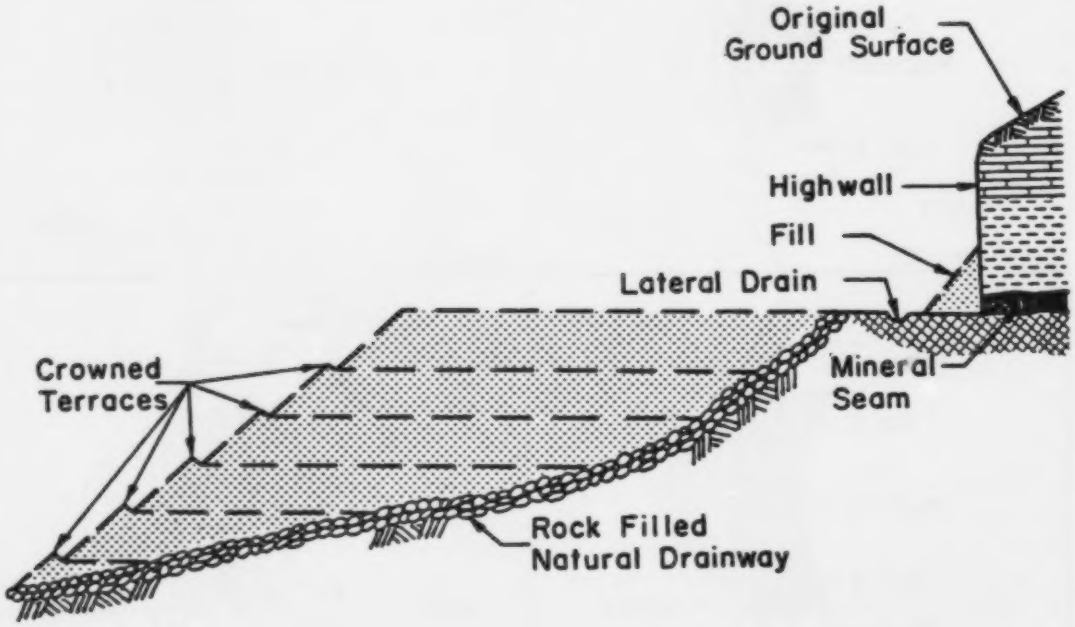

Original Ground Surface
Highwall
Fill
Lateral Drain
Crowned Terraces
Mineral Seam
Rock Filled Natural Drainway

Figure X-2

CROSS SECTION OF TYPICAL HEAD-OF-HOLLOW FILL

Source: (1)

Regrading

The purposes of regrading include the following:

(a) Aesthetic improvement of the land surface

(b) Returning the land to usefulness

(c) Providing a suitable base for revegetation

(d) Burial of pollution-forming materials

(e) Reducing erosion

(f) Eliminating landsliding

(g) Encouraging natural drainage

(h) Eliminating ponding

(i) Eliminating hazards, such as high cliffs, deep pits and deep ponds

(j) Controlling water pollution.

Regrading, as applied to surface mining, is currently defined as that of reconstructing the approximate original contour.

Regrading is often more difficult in older surface mines where mining was conducted with less regard to environmental concern. For example, spoil was often placed without consideration of future regrading requirements.

Contour strip mines in steep terrain create special problems where the spoil was deposited over the outslope. The terrain becomes difficult to cover with topsoil prior to regrading. Achieving a suitable surface for revegetation on abandoned mines becomes complicated because spoil segregation was rarely practiced. Topsoil usually was not segregated or stockpiled and pollution-producing materials are often well mixed throughout the spoil. This emphasizes the importance of regrading methods such as soil spreading and burying of pollution-forming materials. Revegetation techniques such as soil supplementation and spoil segregation are also important. Practices such as water diversion and sealing both underground mine openings and auger holes in highwalls can eliminate many erosional and/or pollution problems otherwise encountered during regrading and revegetation.

A major characteristic of most open pit mines or quarries is the large area required for disposal of overburden and processing wastes. Usually the required disposal acreage exceeds the actual pit area. Careful management of topsoil and overburden must be maintained for later use in land reclamation. Proper disposal of wastes avoids leaching of toxic materials from waste sites. Revegetation and regrading techniques help avoid water infiltration and severe erosion losses which could eventually result in landslides and severe pollutant loadings in nearby waters. Each of these practices is specified under OSM regulations.

Revegetation

Proper revegetation is one of the most effective pollution and erosional control methods for surface mined lands. Revegetation results in aesthetic improvement, and returns land to agricultural, recreational, or silvicultural usefulness.

A dense ground cover stabilizes the surface with its root system, reduces velocity of surface runoff, and functions as a filter to remove sediment from water flowing over and through it. This vegetative cover will annually contribute organic matter to the surface and can greatly reduce erosion. Eventually the soil profile develops into a complete soil ecosystem. The soil bacteria act as an oxygen barrier by consuming oxygen as it enters the soil from the atmosphere. The amount of pollution formed due to oxidation of materials lying below the soil horizon is thus greatly reduced.

A soil profile also tends to act as a sponge by retaining water near the surface. The retained water acts as a surface coolant as it evaporates from the surface. The resulting decrease in surface temperature enhances vegetative growth. Additionally, water retained at the surface or evaporated from the surface does not pass through underlying spoil material, thereby averting potential pollution problems.

Loss of the topsoil is a major hindrance to revegetation and, therefore, topsoil stockpiling is required by OSM. To protect the stockpile from erosion, OSM regulations require that quick-growing annual and perennial plants be seeded on the pile.

Revegetation can be an entire pollution control plan in some instances, but generally it must be an integral part of more comprehensive plans that incorporate water diversion, overburden segregation, and regrading.

Past revegetation efforts were primarily concerned with planting trees. However, to establish vegetative cover adequately, tree planting must be accompanied by establishment of dense ground covers of grasses and legumes that are compatible with the local plants and local environment. Again, OSM regulations specify many facets of revegetation and reclamation.

Erosion and Sediment Control

The most widely practiced method of erosion control is diversion of water. Diverting streams and surface runoff to avoid contamination from mined or disturbed areas is required by OSM. Diversion involves collection of water before it enters a mine area and conveyance of that water around or through the mine site to a suitable disposal area. Structures used for these purposes include diversion dikes, diversion ditches or swales, diversion pipes, and flumes (4, 5). Flumes and pipes are used mainly in areas of steep terrain or to carry water across regraded areas. A dike, a ridge of compacted soil, is used to simply divert the flow of water, whereas a ditch or diversion system collects the water and transfers it to a suitable disposal area. Erosion can also be controlled by reducing the velocity of the water. This can be done by spreading rip rap over the area, by using check dams, or by using sandbag or straw bale barriers (see Figure X-3). The establishment of vegetation will also decrease erosion damage.

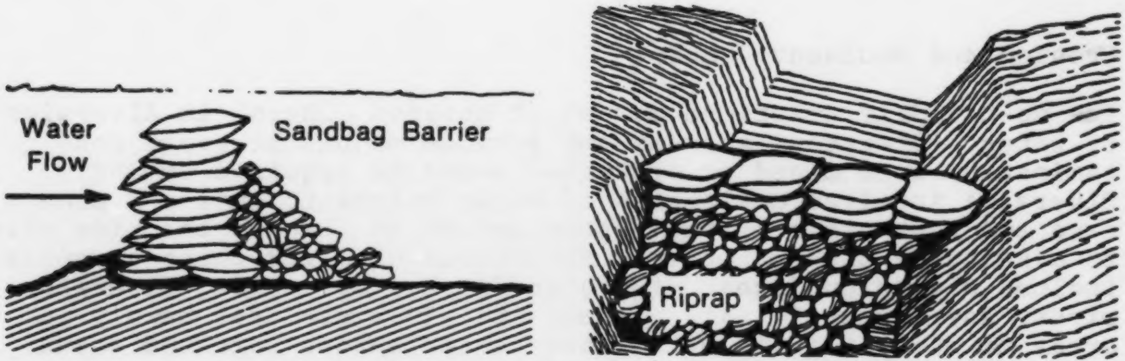
Diversion techniques are directed toward preventing water from entering a mined area. Runoff control employs various methods to handle water after it has reached the mine site. Erosional damage due to runoff can be effectively and inexpensively controlled by the establishment of vegetation. In areas where vegetation cannot be established, rip rap can be used to reduce erosion. Slope reduction and terracing of embankments are also effective in achieving runoff control.

In general, diversion and runoff control methods alone are insufficient to prevent erosion and therefore sedimentation. Methods of sediment control during active mining are needed to remove sediments from the runoff before it is discharged.

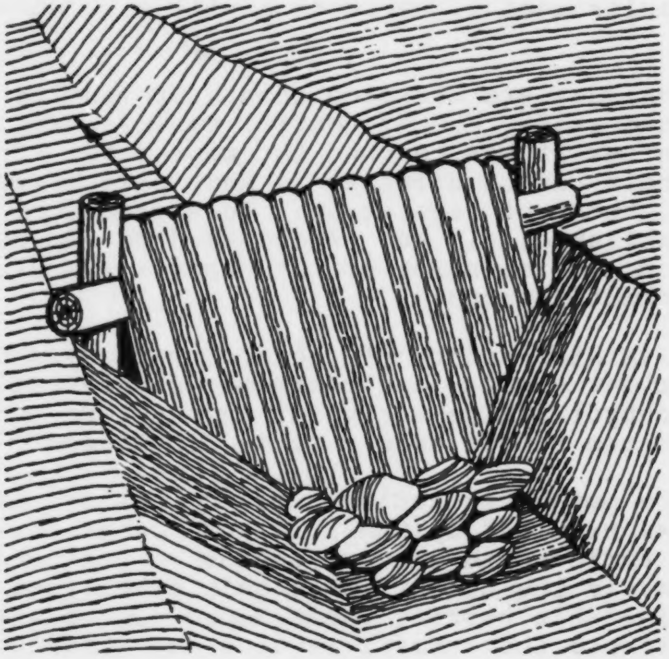
The most common method of sediment control is the use of sedimentation ponds as required by OSM. In some cases, certain techniques may be employed to enhance sedimentation pond performance. One such method is the use of straw bale dikes (see Figure X-3). This is a replaceable barrier constructed out of straw bales. The dike intercepts the runoff, reduces the water's velocity, and detains small amounts of sediment (4). Another technique is the use of in-pond baffles to reduce short circuiting and thereby increase retention time.

Water Infiltration Control

Control of surface infiltration involves either isolating waste material from the water supply or decreasing the surface permeability. Generally, it is not feasible to isolate the large amounts of waste material generated by mining operations. Also, the waste material may be needed as backfill during regrading


Water Flow
Sandbag Barrier
Riprap

A. SANDBAG BARRIERS

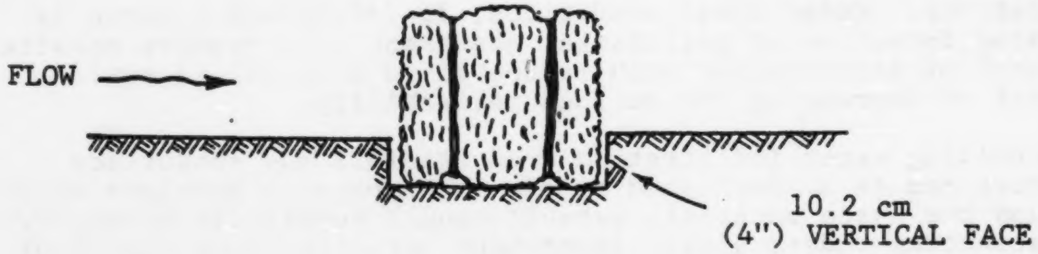


B. LOG CHECK DAM

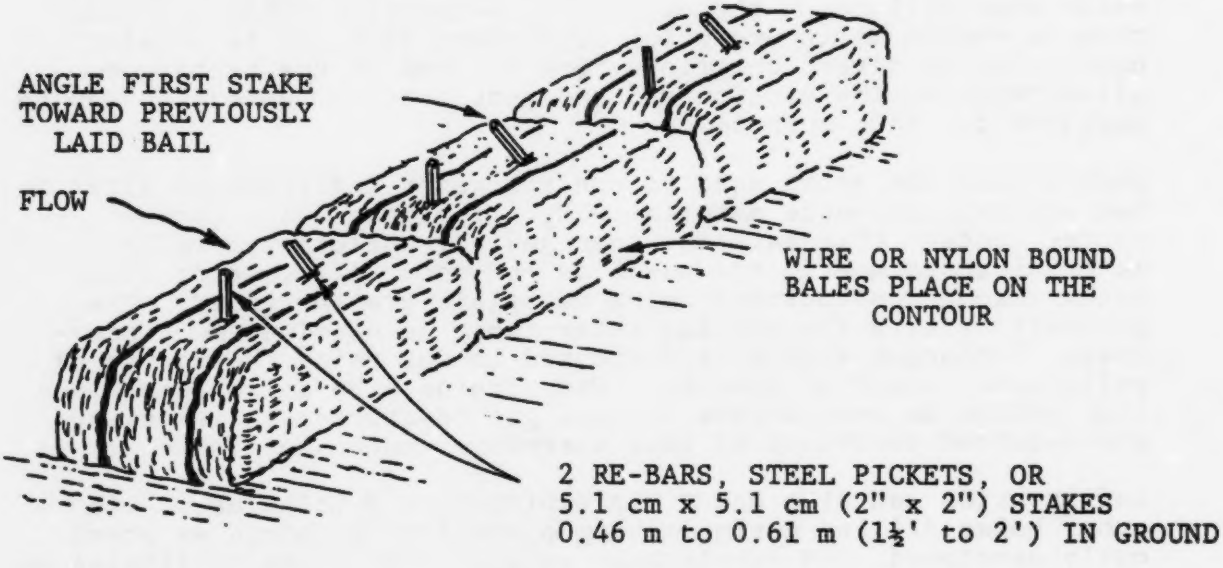
Source: USEPA, Erosion and Sediment Control-Surface Mining in the Eastern U.S., 1976.

Figure X-3

SEDIMENT TRAPS


FLOW
10.2 cm
(4") VERTICAL FACE

EMBEDDING DETAIL


ANGLE FIRST STAKE
TOWARD PREVIOUSLY
LAID BAIL
FLOW
WIRE OR NYLON BOUND
BALES PLACE ON THE
CONTOUR
2 RE-BARS, STEEL PICKETS, OR
5.1 cm x 5.1 cm (2" x 2") STAKES
0.46 m to 0.61 m (1½' to 2') IN GROUND

ANCHORING DETAIL

C. STRAW BALE BARRIER

Figure X-3 (Continued)

SEDIMENT TRAPS

operations. Under these conditions, if infiltrating water is causing formation of pollutants, abatement will require on-site control of infiltration such as contained disposal of toxic wastes or decreasing the surface permeability.

Controlling water infiltration from rainfall and subsurface sources can be accomplished by placing impervous barriers on or around the waste material, establishing a vegetative cover, or constructing underdrains. Impervious barriers, constructed of clay, concrete, asphalt, latex, plastic, or formed by special processes such as carbonate bonding, can prevent water from reaching the waste material.

A dense vegetative cover has varying effects on infiltration. For instance, vegetation tends to reduce the velocity of water, thereby inducing infiltration. Conversely, a vegetative cover will build up a soil profile, which tends to increase the surface retention of water. This water is available for evaporation and can result in a net decrease in the amount of water entering underlying materials. Vegetation also utilizes large quantities of water in its life processes (again decreasing the amount of water that will reach the underlying material). When infiltration is caused by interception of surface flow, it is usually beneficial to divert the flow. One or more of the techniques illustrated in the erosion and sediment control subsection may be employed for this purpose.

Underdrains are often used to control water infiltration after it has entered the waste material. By offering a quick escape route, contact time between water and any pollutant-forming material contained in the waste is reduced. Also, water flow paths through pollution-forming materials are shortened. The possibility of a fluctuating water table is eliminated. Underdrain discharges should be monitored to determine the nature of pollutants contained therein. Underdrains also serve as collection points to concentrate diffuse groundwater drainage making any required treatment of this wastewater more manageable.

Infiltration can also occur via exploration drillholes or via other holes drilled during mining operations although as previously mentioned, OSM regulations require that these drillholes be cased, sealed or otherwise managed in a manner that avoids drainage into groundwater.

SECTION XI

BEST CONVENTIONAL POLLUTANT CONTROL TECHNOLOGY

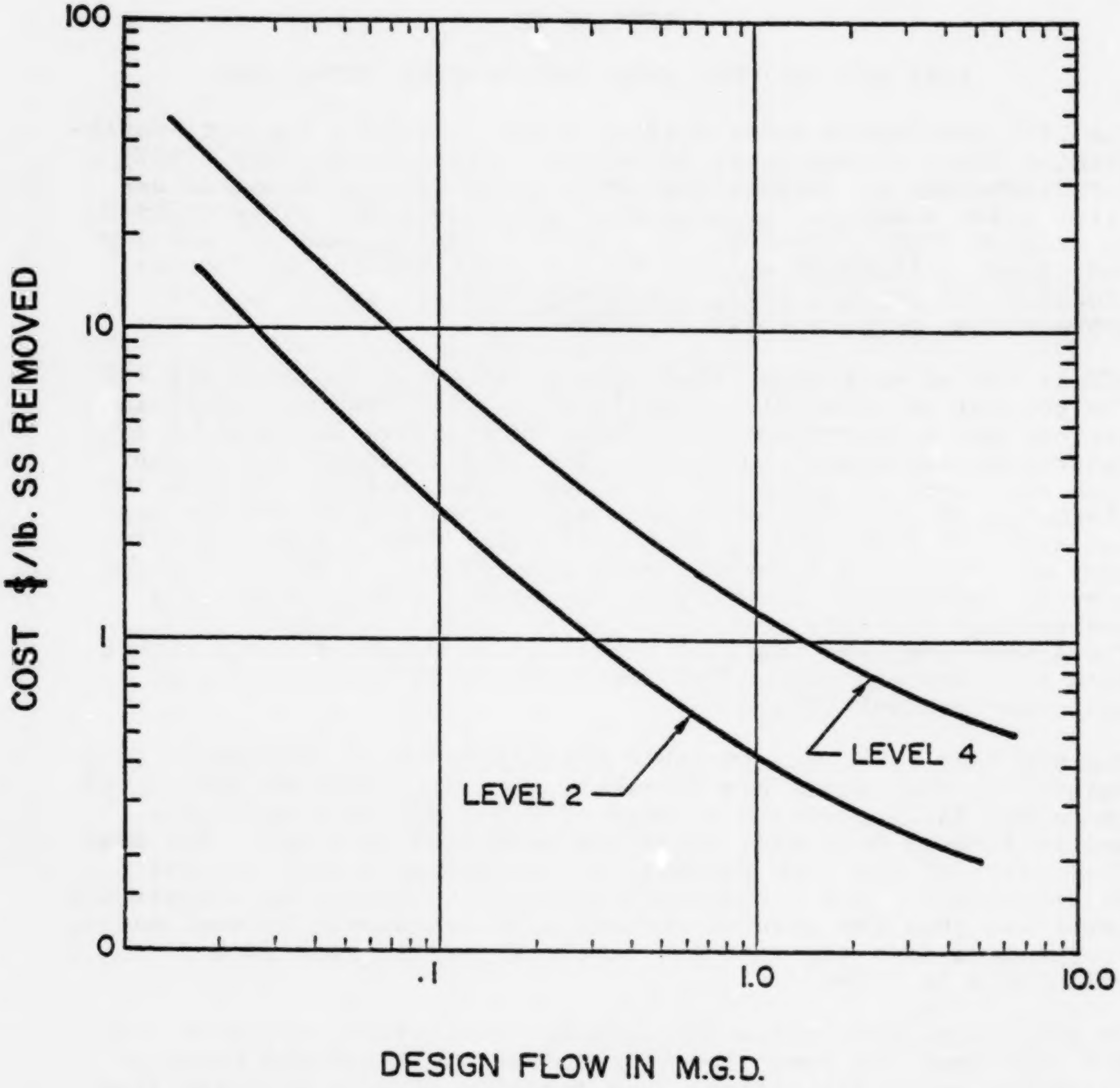
The 1977 amendments added Section 301(b)(4)(E) to the Act, establishing "best conventional pollutant control technology" (BCT) for discharges of conventional pollutants from existing industrial point sources. Conventional pollutants are those defined in Section 304(b)(4)--BOD, TSS, fecal coliform, and pH--and any additional pollutants defined by the Administrator as "conventional." On 30 July 1978, EPA designated oil and grease as a conventional pollutant (44 FR 44501).

BCT is not an additional limitation; rather it replaces BAT for the control of conventional pollutants. BCT requires that limitations for conventional pollutants be assessed in light of a "cost-reasonableness" test which involves a comparison of the cost and level of reduction of conventional pollutants from the discharge of publicly owned treatment works (POTWs) to the cost and level of reduction of such pollutants from a class or category of industrial sources. As a part of its review of BAT for certain "secondary" industries, the Agency has promulgated a methodology for this cost test (44 FR 50732, 29 August 1979). The Agency compares costs with that of an "average" POTW with a flow of 2 mgd and costs (1979 dollars) of $1.51 per pound of pollutant removal (TSS).

The BCT test is of questionable utility for this industry. Flow volumes at coal mines are extremely variable, with 90 percent of the mines falling within a range of 0.006 mgd to 5 mgd. The median flow is 0.25 mgd, while the mean flow is 1 mgd. The mean flow falls at the 75th percentile, indicating a very unequal distribution. This variability makes it difficult to compare the level and thus the cost of reduction of pollutants in coal mining wastewaters with the cost and level of reducing the same pollutants in POTWs.

In compliance with statutory factors, the Agency completed the BCT cost test for Level Two (flocculant addition) and Level 4 (granular media filtration) as a function of mine drainage flow rate. The results are presented in Figure XI-1 and Table XI-1. Higher flow rates significantly reduce the cost per pound of treatment.

As explained in Section X, the Agency has not selected either Level 2 or Level 4 as BAT technology, but will retain BPT as the best available technology. Also, the technologies considered for conventional pollutant removal are identical to those considered for toxic pollutant removal. These two factors establish, by definition, that the best conventional pollutant control technology for this industry meets the BCT cost test.



Level 2 - Flocculant Addition
Level 4 - Granular Media Filtration

Figure XI-1

BCT COST CURVES

Table XI-1

COAL MINING, POINT SOURCE CATEGORY
COST PER POUND OF TSS REMOVED
BCT TEST

Flow (MGD)	LEVEL 2 - SS(EFFL): 20 PPM				LEVEL 4 - SS(EFFL): 10 PPM			
	Capital Cost $	Yearly Cost $	lbs/yr SS Removed	$/lb	Capital Cost $	Yearly Cost $	lbs/yr SS Removed	$/lb
0.02	30,000	12,000	913	13.7	120,000	49,000	1,522	32.2
0.25	30,000	13,830	11,412	1.2	199,000	64,500	19,025	3.4
1.0	40,000	20,330	45,296	.45	280,000	95,000	76,100	1.2
2.0	40,000	26,420	91,296	.29	380,000	130,000	152,200	.85
4.5	40,000	41,615	205,416	.20	600,000	198,500	342,450	.58

ASSUMPTIONS:

1. Existing Mine with BPT facilities in place
2. Type: Acid-surface
3. Region 6 or 7: cost multiplier 1.0
4. Flocculant Aid: 1 ppm at $2.00/lb
5. Filters at 12 gpm/ft^2
6. Suspended solids influent: 35 ppm
7. lb/yr TSS removed: 8.34 x ppm removal x 365 x MGD
8. The following capital recovery factors have been used: 0.16275 for equipment (or 10 percent interest rate for 10 yrs.) 0.10608 for construction (or 10 percent interest rate for 30 yrs.)
9. Operating personnel: an hourly rate of $12.00 (including fringe benefits, overhead, and supervision) and 2080 hrs/yr
10. Materials and supplies at 3 percent of capital cost
11. Electricity cost at $0.03/kwhr
12. 1979 dollars

SECTION XII

NEW SOURCE PERFORMANCE STANDARDS (NSPS)

The basis for new source performance standards (NSPS) under Section 306 of the Act is through application of the best available demonstrated technology. New mining facilities have the opportunity to implement the best and most efficient coal mining processes and wastewater technologies. Congress, therefore, directed EPA to consider the best demonstrated process changes and end-of-pipe treatment technologies capable of reducing pollution to the maximum extent feasible.

New source performance standards were proposed on 13 May 1976 (41 FR 19841) and 19 September 1977 (42 FR 46932) and promulgated on 12 January 1979 (44 FR 2586). The Agency has reviewed these standards and established a number of options.

NSPS OPTIONS CONSIDERED

The Agency considered the following four NSPS options:

Option One. Require achievement of performance standards in each subcategory based on the same technology proposed for BAT, including neutralization and settling for acidic wastewaters. This option is predicated on application of the same technology proposed for BPT for the acid drainage and preparation plant and associated areas subcategories. The alkaline drainage and areas under reclamation subcategories would be required to meet performance standards based on settling technology. No additional expenditures would be required from selection of this option.

Option Two. Require achievement of performance standards based on flocculant addition. As discussed in Section X, this technology would provide some additional reduction of solids, but would not provide a cost-effective decrease in toxic pollutant levels, which were found to be extremely low.

Option Three. Require achievement of performance standards based on granular media filtration. As in the case of Option Two, granular media filtration would provide some additional reduction of solids, but would not provide a cost-effective decrease in toxic pollutant levels.

Option Four. Require achievement of no discharge of process wastewater pollutants in the coal preparation plant subcategory with one of the other options selected for the mine drainage subcategories. Economic and environmental considerations have already provided the incentive to design processes in existing preparation plants which partially or completely reuse process water. The zero discharge requirement would prohibit the

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discharge of any pollution-bearing streams from the preparation plant water circuit, including the treatment system. No storm exemption would be available.

NSPS SELECTION AND DECISION CRITERIA

EPA has selected Options One and Four as the basis for proposed new source performance standards. The rationale for selecting Option One was discussed in Section X. In Option Four, the preparation plant subcategory is separated from the associated areas subcategory for new sources. Many existing facilities are practicing total recycle of preparation plant wastewaters, thus zero discharge is a demonstrated technology for these facilities. Further, this option becomes feasible for new sources because treatment system and water management planning can be implemented from the design phase, eliminating the economic and technical inefficiency associated with retrofitting.

The new source performance standards corresponding to Options One and Four may be found in Section X.

SECTION XIII

PRETREATMENT STANDARDS

Section 307(b) of the Act requires EPA to promulgate pretreatment standards for both existing sources (PSES) and new sources (PSNS) of pollution which discharge their wastes into publicly owned treatment works (POTWs). These pretreatment standards are designed to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with the operation of POTWs. In addition, the Clean Water Act of 1977 adds a new dimension to these standards by requiring pretreatment of pollutants, such as heavy metals, that limit POTW sludge management alternatives. The legislative history of the Act indicates that pretreatment standards are to be technology based and, with respect to toxic pollutants, analogous to BAT. The Agency has promulgated general pretreatment regulations which establish a framework for the implementation of these statutory requirements (see 43 FR 27736, 16 June 1978).

EPA is not proposing pretreatment standards for existing sources (PSES) in the coal mining point source category at this time nor does it intend to promulgate such standards in the future (PSNS) since there are no known or anticipated dischargers to publicly owned treatment works (POTWs). Coal mines are located in rural areas, often far from population centers and publicly owned treatment plants. No rational mine operator would choose to route the high volume mine discharge to a POTW for treatment. This is true for existing sources and will continue to be true for new sources, and thus pretreatment standards would be irrelevant and unnecessary.

SECTION XIV

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1. All regional offices
2. Industrial Environmental Research Laboratory
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3. Office of Research and Development
4. Office of General Counsel
5. Office of Analysis and Evaluation
6. Monitoring and Data Support
7. Criteria and Standards Division

Pennsylvania Department of Environmental Resources

Bituminous Coal Research

National Coal Association

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Bill's Coal Company
Buffalo Mining Company
Central Ohio Coal Company
Clemens Coal Company
Consolidation Coal Company
Drummond Coal Company
Duquesne Light Company
Eastern Associates Coal Company
Falcon Coal Company
Harmar Coal Company
Industrial Generating Company
Inland Steel Coal Company
Island Creek Coal Company
Jewell Ridge Coal Company
Jones & Laughlin Steel Corporation
Kaiser Steel
Kentland Coal Corporation
King Knob Coal Company
Knife River Coal Company
Monterey Coal Company
National Mines Corporation
North American Coal Company
Old Ben Coal Company
Peabody Coal Company
Peter Kiewit & Sons, Incorporated
Pittston Coal Company
Southwestern Illinois Coal Company
U.S. Steel
V. & J. Carlson
Washington Irrigation & Development Company
Western Energy Company

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SECTION XVI

GLOSSARY

absorption: The process by which a liquid is drawn into and tends to fill permeable pores in a porous solid body; also the increase in weight of a porous solid body resulting from the penetration of liquid into its permeable pores.

acid: A substance which dissolves in water with the formation of hydronium ion. A substance containing hydrogen which may be displaced by metals to form salts.

acid mine drainage (AMD): Synonomous with "ferruginous mine drainage." That drainage which before any treatment has a pH of less than 6.0 or a total iron concentration of more than 10.0 mg/l.

acidity: The quantitative capacity of aqueous solutions to react with hydroxyl ions (OH^-). The condition of a water solution having a pH of less than 7.

acre-foot: A term used in measuring the volume of water that is equal to the quantity of water required to cover 1 acre 1 foot deep, or 43,560 ft^3.

Act: The Federal Water Pollution Control Act, as amended (33 U.S.C. 1251, 1311 and 1314(b) and (c), P.L. 92-500). Also called the Clean Water Act and amendments through 1977.

activated carbon: Carbon which is treated by high-temperature heating with steam or carbon dioxide producing an internal porous particle structure. Activated carbon is often used to adsorb organic pollutants and/or remove metal ions.

active mining area: An area where work or other activity relating to the extraction, removal or recovery of any coal is being conducted. This includes areas where secondary recovery of coal is being conducted, but specifically does not include for surface mines any area of land on or in which grading to return the land to the desired contour has been completed and reclamation work has begun.

Administrator: Administrator of the U.S. Environmental Protection Agency, whose duties are to administer the Act.

adsorption: The adhesion of an extremely thin layer of molecules (of gas, liquid) to the surfaces of solids (granular activated carbons for instance) or liquids with which they are in contact.

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alkaline mine drainage: That mine drainage which before any treatment has a pH of more than 6.0 and a total iron concentration of less than 10.0 mg/l.

advanced waste treatment: Any treatment method or process employed following biological treatment (1) to increase the removal of pollution load, (2) to remove substances which may be deleterious to receiving waters or the environment, (3) to produce a high-quality effluent suitable for reuse in any specific manner or for discharge under critical conditions. The term tertiary treatment is commonly used to denote advanced waste treatment methods.

aerated pond: A natural or artificial wastewater treatment pond in which mechanical or diffused air aeration is used to supplement the oxygen supply.

aeration: The bringing about of intimate contact between air and liquid by one of the following methods: spraying the liquid in the air, bubbling air through the liquid (diffused aeration), agitation of the liquid to promote surface absorption of air (mechanical aeration).

agglomeration: The coalesence of dispersed suspended matter into larger flocs or particles which settle more rapidly.

alkalinity: The capacity of water to neutralize acids, a property imparted by the water's content of carbonates, bicarbonates, hydroxides, and occasionally borates, silicates, and phosphates. It is expressed in milligrams per liter of equivalent calcium carbonate.

anion: The charged particle in a solution of an electrolyte which carries a negative charge.

anion exchange process: The reversible exchange of negative ions between functional groups of the ion exchange medium and the solution in which the solid is immersed. Used as a wastewater treatment process for removal of anions, e.g., carbonate.

anthracite: A hard natural coal of high luster which contains little volatile matter, and greater than 92% fixed carbon.

anticline: A fold that is convex upward. The oldest strata are closest to the axial plane of the fold.

aquifer: A subsurface rock formation that is capable of producing water.

areas under reclamation: A previously surface mined area where regrading has been completed and revegetation has commenced.

asbestos minerals: Certain minerals which have a fibrous structure, are heat resistant, chemically inert and possessing high electrical insulating qualities. The two main groups are serpentine and amphiboles. Chrysotile (fibrous serpentine, $3MgO . 2SiO_2 . 2H_2O$) is the principal commercial variety. Other commercial varieties are armosite, crocidolite, actinolite, anthophyllite, and tremolite.

auger: Any drilling device in which the cuttings are mechanically and continuously removed from the borehole without the use of fluids; usually used for shallow drilling or sampling.

auger mining: Spiral boring for additional recovery of a coal seam exposed in a highwall.

backfilling: The transfer of previously moved material back into an excavation such as a mine or ditch, or against a constructed object.

backwashing: The process of cleaning a rapid sand or mechanical filter by reversing the flow of water.

base: A compound which dissolves in water to yield hydroxyl ions (OH^-).

bench: The surface of an excavated area at some point between the material being mined and the original surface of the ground on which equipment can be set, move or operate. A working road or base below a highwall as in contour stripping for coal.

best available technology economically achievable (BATEA or BAT): The level of technology applicable to effluent limitations to be achieved by July 1, 1984, for industrial discharges to surface waters as defined by Section 301(b) (2) (A) of the Act.

best practicable control technology currently available (BPCTCA or BPT): Treatment required by July 1, 1977 for industrial discharge to surface waters as defined by Section 301(b) (1) (A) of the Act.

best available demonstrated technology (BADT): Treatment rquired for new sources as defined by Section 306 of the Act.

biochemical oxygen demand (BOD): A measure of water contamination expressed as the amount of dissolved oxygen (mg/l) required by microorganisms, during stabilization of organic matter by aerobic chemical action.

bituminous: A coal of intermediate hardness containing between 50 and 92 percent fixed carbon.

blowdown: A portion of water in a closed system which is removed or discharged in order to prevent a buildup of dissolved solids.

carbon absorption: A process utilizing the efficient absorption characteristics of activated carbon to remove both dissolved and suspended substances.

cation: The positively charged particles in solution of an electrolyte.

cationic flocculant: In flocculation, surface active substances which have the active constituent in the positive ion. Used to flocculate and neutralize the negative charge residing on colloidal particles.

chemical analysis: The use of a standard chemical analytical procedure to determine the concentration of a specific pollutant in a wastewater sample.

chemical coagulation: The destabilization and initial aggregation of colloidal and finely divided suspended matter by the addition of a floc-forming chemical.

chemical oxygen demand (COD): A specific test to measure the amount of oxygen required for the complete oxidation of all organic and inorganic matter in a water sample which is susceptible to oxidation by a strong chemical oxidant.

chemical precipitation: (1) Precipitation induced by addition of chemicals. This includes the reaction of dissolved substances such that they pass out of solution into the solids phase. (2) The process of softening water by the addition of lime and soda ash as the precipitants.

chrysotile: A mineral of the serpentine group, $Mg_3Si_2O_5(OH)_4$.

clarification: A physical-chemical wastewater treatment process involving the various steps necessary to form a stable, rapid settling floc and to separate it by sedimentation. Clarification may involve pH adjustment, precipitation, coagulation, flocculation, and sedimentation.

clarifier: A basin usually made of steel in which water flows at a low velocity to allow settling of suspended matter.

coagulation: The treatment process by which a chemical added to wastewater acts to neutralize the repulsive forces that hold waste particles in suspension.

coagulants: Materials that induce coagulation and are used to precipitate solids or semi-solids. They are usually compounds which dissociate into strongly charged ions.

coal mine: An area of land with all property placed upon, under or above the surface of such land, used in or resulting from the work of extracting coal from its natural deposits by any means or method including secondary recovery of coal from refuse or other storage piles derived from mining, cleaning, or preparation of coal.

coal mine drainage: Any water drained, pumped or siphoned from a coal mine.

coal pile drainage: Drainage from a coal pile as a result of percolation or runoff from rainfall.

colloids: Suspensions of particles, usually between a nanometer and a micrometer in diameter, in any physical state. In this size range the surface area is so great compared to the volume that unusual phenomenon occur, i.e., particles do not settle out by gravity and are small enough to pass through normal filter membranes (i.e., not ultrafilters).

composite wastewater sample: A combination of individual samples of water or wastewater taken at selected intervals, generally hourly for some specified period, to minimize the effect of the variability of the individual sample. Individual samples may have equal volume or may be roughly proportioned to the flow at time of sampling.

concentration, hydrogen ion: The weight of hydrogen ions in grams per liter of solution. Commonly expressed as the pH value that represents the logarithm of the reciprocal of the hydrogen ion concentration.

conventional pollutants: pH, BOD, fecal coliform, oil and grease, and TSS.

crusher, jaw: A primary crusher designed to reduce the size of materials by impact or crushing between a fixed plate and an oscillating plate or between two oscillating plates, forming a tapered jaw.

crusher, roll: A reduction crusher consisting of a heavy frame on which two rolls are mounted; the rolls are driven so that they rotate toward one another. Coal is fed in from above and nipped between the moving rolls, crushed, and discharged below.

cyclone: (a) The conical-shaped apparatus used in dust collecting operations and fine grinding applications; (b) A classifying (or concentrating) separator into which pulp is fed, so as to take a circular path. Coarser and heavier fractions of solids report as the apex of long cone while finer particles overflow from central vortex.

data correlation: The process of the conversion of reduced data into a functional relationship and the development of the significance of both the data and the relationship for the purpose of process evaluation.

decant structure: Apparatus for removing clarified water from the surface layers of tailings or settling ponds.

deep mine: An underground mine.

dense-media separation: (a) Heavy media separation, or sink float. Separation of heavy sinking from light floating mineral particles in a fluid of intermediate density; (b) Separation of relatively light (floats) and heavy particles (sinks), by immersion in a bath of intermediate density.

denver cell: A flotation cell of the subaeration type, in wide use. Design modifications include receded disk, conical-disk, and multibladed impellers, low-pressure air attachments, and special froth withdrawal arrangements.

denver jig: Pulsion-suction diaphragm jig for fine material, in which makeup (hydraulic) water is admitted through a rotary valve adjustable as to portion of jigging cycle over which controlled addition is made.

dependent variable: A variable whose value is a function of one or more independent variables.

deposit: Mineral, coal or ore deposit is used to designate a natural occurrence of a useful mineral, coal, or an ore, in sufficient extent and degree of concentration to permit exploitation.

depressing agent; depressor; depressant: In the froth flotation process, a substance which reacts with the particle surface to render it less prone to stay in the froth, thus causing it to wet down as a tailing product (contrary to activator).

detention time: The time allowed for solids to collect in a settling tank. Theoretically , detention time is equal to the volume of the tank divided by the flow rate. The actual detention time is determined by operating parameters of the tank.

dewater: To remove a portion of the water from a sludge or a slurry.

differential flotation: Separating a raw coal into two or more coals and pyrites by flotation; also called selective flotation. This type of flotation is made possible by the use of suitable depressors and activators.

discharge: Outflow from a pump, drill hole, piping system, channel, weir or other discernible, confined or discrete conveyance (see also point source).

discharge pipe: A section of pipe or conduit from the condenser discharge to the point of discharge into receiving waters or cooling device.

dispersing agent: Reagent added to flotation circuits to prevent flocculation, especially of objectionable colloidal slimes. Sodium silicate is frequently added for this purpose.

dissolved solids: Theoretically, the anhydrous residues of the dissolved constituents in water. Actually, the term is defined by the method used in determination. In water and wastewater treatment, the Standard Methods tests are used.

disturbed area: An area which has had its natural condition altered in the process of mining coal, preparing coal, or other mine related activities. This includes but is not limited to all areas affected by grubbing and topsoil removal; road construction; construction of mine facilities; coal mining, reclamation and preparation activities; deposition of topsoil, overburden, coal or waste materials, etc. These areas are classified as "disturbed" until said areas have been returned to approximate original contour (or post-mining land use) and topsoil (where appropriate) has been replaced.

dragline: A piece of excavating equipment which employs a cable-hung bucket to remove overburden.

drift: A deep mine entry driven directly into a horizontal or near horizontal mineral seam or vein when it outcrops or is exposed at the ground surface.

effluent: Liquid, such as wastewater, treated or untreated which flows out of a unit operation, reservoir or treatment plant. The influent is the incoming stream.

eluate: Solutions resulting from regeneration (elution) of ion exchange resins.

eluent: A solution used to extract collected ions from an ion exchange resin or solvent and return the resin to its active state.

embankment (or impoundment): Storage basin made to contain wastes from mines or preparation plants.

erosion: Processes whereby solids are removed from their original location on the land surface by hydraulic or wind action.

filter, granular: A device for removing suspended solids from water, consisting of granular material placed in a layer(s) and capable of being cleaned by reversing the direction of the flow.

filter, rapid sand: A filter for the purification of water which has been previously treated, usually by coagulation and sedimentation. The water passes downward through a filtering medium consisting of a layer of sand, prepared anthracite coal or other suitable material, usually from 24 to 30 inches thick and resting on a supporting bed of gravel or other porous medium. The filtrate is removed by an underdrain system. The filter is cleaned periodically by reversing the flow of the water upward through the filtering medium; sometimes supplemented by mechanical or air agitation during backwashing to remove mud and other impurities that are lodged in the sand.

filter, vacuum: A filter consisting of a cylindrical drum mounted on a horizontal axis, covered with a filter cloth revolving with a partial submergence in liquid. A vacuum is maintained under the cloth for the larger part of a revolution to extract moisture and the cake is scraped off continuously.

filtration: The process of passing a liquid through a filtering medium for the removal of suspended or colloidal matter.

final contour: The surface shape or contour of a surface mine (or section thereof) after all mining and earth moving (regrading) operations have been completed.

floc: A very fine, fluffy mass formed by the aggregation of fine suspended particles.

flocculants: Any substance which will cause flocculation. They are specifically useful in wastewater treatment. Lime, alum, and ferric chloride are examples of inorganic flocculants and polyelectrolytes are organic flocculants.

flocculate: To cause to aggregate or to coalesce into small lumps or loose clusters, e.g., the calcium ion tends to flocculate clays.

flocculation: In water and wastewater treatment, the agglomeration of colloidal and finely divided suspended matter after coagulation by gently stirring by either mechanical or hydraulic means.

flotation: The method of coal or mineral separation in which a froth created in water by a variety of reagents floats some finely crushed coal or minerals, whereas pyrites and other minerals sink.

flotation agent: A substance or chemical which alters the surface tension of water or which makes it froth easily. The reagents used in the flotation process include pH regulators, slime dispersants, resurfacing agents, wetting agents, conditioning agents, collectors, and frothers.

flume: An open channel or conduit on a prepared grade.

froth, foam: In the flotation process, a collection of bubbles resulting from agitation, the bubbles being the agenct for raising (floating) the particles of coal or ore to the surface of the cell.

frother(s): Substances used in flotation processes to make air bubbles sufficiently permanent principally by reducing surface tension. Common frothers are pine oil, creyslic acid, and amyl alcohol.

flow model: A mathematical model of the effluent wastewater flow, developed through the use of multiple linear regression techniques.

flow rate: Usually expressed as liters/minute (gallons/minute) or liters/day (million gallons/day). Design flow rate is that used to size the wastewater treatment process. Peak flow rate is 1.5 to 2.5 times design and relates to the hydraulic flow limit and is specified for each plant. Flow rates can be mixed as batch and continuous where these two treatment modes are used in the same plant.

frequency distribution: An arrangement or distribution of quantities pertaining to a single element in order of their magnitude.

grab sample: A single sample of wastewater taken at neither a set time nor flow.

gravity separation: Treatment of coal or mineral particles which exploits differences between their specific gravities. Their sizes and shapes also play a minor part in separation. Performed by means of jigs, classifiers, hydrocyclones, dense media, shaking tables, Humphreys spirals, sluices, vanners and briddles.

grinding: (a) Size reduction into relatively fine particles. (b) Arbitrarily divided into dry grinding performed on coal or mineral containing only moisture as mined, and wet grinding, usually done in rod, ball or pebble mills with added water.

groundwater table (or level): Upper surface of the underground zone of saturation.

grout: A fluid mixture of cement, sand (or other additives) and water that can be poured or pumped easily.

hardness: A characteristic of water, imparted by salts of calcium, magnesium, and iron, such as bicarbonates, carbonates, sulfates, chlorides, and nitrates, that causes curdling of soap, deposition of scale in boilers, damage in some industrial process, and sometimes objectionable taste. It may be determined by a standard laboratory procedure or computed from the amounts of calcium and magnesium as well as iron, aluminum, manganese, barium, strontium, and zinc, and is expressed as equivalent calcium carbonate.

heavy-media separation: See dense-media separation.

highwall: The unexcavated face of exposed overburden and coal in a surface mine or the face or bank on the uphill side of a contour strip mine excavation.

hydrocyclone: A cyclone separator in which a spray of water is used.

hydroclassifier: A machine which uses an upward current of water to remove fine particles from coarser material.

hydrology: The science that relates to the water systems of the earth.

independent variable: A variable whose value is not dependent on the value of any other variable.

influent: The liquid, such as untreated or partially treated wastewater, which flows into a reservoir, process unit, or treatment plant. The effluent is the outgoing stream.

in-plant control: Those treatment techniques that are used to reduce, reuse, recycle, or treat wastewater prior to end-of pipe treatment.

ion: A charged atom, molecule or radical, the migration of which affects the transport of electricity through an electrolyte.

ion exchange: A chemical process involving reversible interchange of ions between a liquid and solid but no radical change in the structure of the solid.

jig: A machine in which the feed is stratified in water by means of a pulsating motion and from which the stratified products are separately removed, the pulsating motion being usually obtained by alternate upward and downward currents of the water.

jigging: A process used to separate coarse materials in the coal or ore by means of differences in specific gravity in a water medium.

lagoon: Man-made ponds or lakes usually 4 feet deep (or up to 18 feet if aerated) which are used for storage, treatment, or disposal of wastes. They can be used to hold wastewater for removal of suspended solids, to store sludge, cool water, or for stabilization of organic matter by biological oxidation. Lagoons can also be used as holding ponds, after chemical clarification and to polish the effluent.

lignite: A carbonaceous fuel ranked between peat and bituminous coal.

lime: Any of a family of chemicals consisting essentially of calcium hydroxide made from limestone (calcite) which is composed almost wholly of calcium carbonate or a mixture of calcium and magnesium carbonates.

lime slurry: A form of calcium hydroxide in aqueous suspension that contains free water.

linear regression: A method to fit a line through a set of points such that the sum of squared vertical deviations of the point values from the fitted line is a minimum, i.e., no other line, no matter how it is computed, will have a smaller sum of squared distances between the actual and predicted values of the dependent variable.

magnetic separator: A device used to separate magnetic from less magnetic or nonmagnetic materials.

mathematical model: A quantitative equation or system of equations formulated in such a way as to reasonably depict the structure of a situation and the relationships among the relevant variables.

mean value: The statistical expected or average figure.

median value: A data observation located at the 50th percentile or the midrange.

mesh size (activated carbon): The particle size of granular activated carbon as determined by the U.S. Sieve series. Particle size distribution within a mesh series is given in the specification of the particular carbon.

milligrams per liter (mg/l): This is a mass per volume designation used in water and wastewater analysis.

minable: (a) Capable of being mined. (b) Material that can be mined under present day mining technology and economics.

mine: (a) An opening or excavation in the earth for the purpose of excavating minerals, coals, metal ores or other substance by digging. (b) A word for the excavation of minerals by means of pits, shafts, levels, tunnels, etc., as opposed to a quarry, where the whole excavation is open. In general the existence of a mine is determined by the mode in which the mineral is obtained, and not by its chemical or geologic character. (c) An excavation beneath the surface of the ground from which mineral matter of value is extracted.

mine drainage: Mine drainage usually implies gravity flow of wastewater from coal mining to a point away from the mining operation. However, this term encompasses any wastewater emanating from a coal mining or preparation operation.

mixed-media filtration: A filter which uses two or more filter materials of differing specific gravities selected so as to produce a filter uniformly graded coarse to fine.

mulching: The addition of materials (usually organic) to the land surface to curtail erosion or retain soil moisture.

multiple linear regression: A method to fit a plant through a set of points such that the sum of squared distances between the individual observations and the estimated plane is a minimum. This statistical technique is an extension of linear regression in that more than one independent variable is used in the least squares equation.

neutralization: Adjustment of pH by the addition of acid or alkali until a pH of about 7.0 is achieved. See pH adjustment.

new source: Any point source, the construction of which is begun after the publication of proposed Section 306 regulations.

new source performance standard (NSPS): Performance standards for the industry and applicable new sources as defined by Section 306 of the Act.

NPDES permits: National Pollutant Discharge Elimination System Permits are issued by the EPA or an approved state program in order to regulate point-source discharge to public waters.

nonconventional pollutants: Chemical or thermal pollutants, principally defined by not being a conventional or toxic pollutant.

normalized coefficients: Regression constants whose magnitudes are referenced to some value.

open-pit mining, open cut mining: A form of operation designed to extract coal or minerals that lie near the surface. Waste, or overburden, is first removed, and the coal or mineral is broken and loaded.

osmosis: The process of diffusion of a solvent through a semipermeable membrane from a solution of lower to one of higher solute concentration.

osmotic pressure: The equilibrium pressure differential across a semipermeable membrane which separates a solution of lower from one of higher concentration.

outcrop: The exposing of bedrock or strata projecting through the overlying cover of detritus and soil.

outfall: The point or location where sewage or drainage discharges from a sewer, drain or conduit.

overburden: Material of any nature, consolidated or unconsolidated, that overlies a deposit of useful materials (i.e., coal, ores, etc.).

overflow: Excess water discharged from the treatment system.

oxidation: The addition of oxygen to a chemical compound, or any reaction which involves the loss of electrons from an atom.

oxidized zone: In coal mining, that portion of a refuse pile near the surface, which has been leached by percolating water carrying oxygen, carbon dioxide or other gases.

permeability: Capacity for transmitting a fluid.

pH: A measure of the acidity or alkalinity of an aqueous solution, generally expressed in terms of the hydrogen ion ($H+$) or hydronium ion (H_3O+) content. A pH of below 7 is considered an acidic solution; and above 7 it is considered an alkaline solution.

pH adjustment: Treatment of wastewater by the addition of an acid or alkali to effect a change in the pH or hydrogen ion concentration. Alkalis such as lime (CaO), limestone ($CaCO_3$), caustic soda ($NaOH$), or soda ash (Na_2CO_3), which supply hydroxyl ions are used to adjust acidic streams while an acid, usually sulfuric (H_2SO_4) or hydrochloric (HCl) reacts, with alkaline streams by supplying hydrogen ions.

pH modifiers: Proper functioning of a cationic or anionic flotation reagent is dependent on the close control of pH. Modifying agents used are soda ash, sodium hydroxide, sodium silicate, sodium phosphates, lime, sulfuric acid, and hydrofluoric acid.

pH value: A scale for expressing the acidity or alkalinity of a solution. Mathematically, it is the logarithm of the reciprocal of the gram ionic hydrogen equivalents per liter. Neutral water has a pH of 7.0 and hydrogen ion concentration of 10^{-7} moles per liter.

physical-chemical treatment: In this study, it is taken to mean a method of treating wastewater by the addition of chemicals to physically separate the pollutant from a stream, usually by precipitation, followed by settling or flotation of the wastes. To accomplish this, several processes may be utilized such as pH adjustment, reduction of hexavalent chromium, heavy-metal precipitation, coagulation, flocculation, and clarificaiton by settling.

point source: Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.

preparation plant: A facility that cleans, sizes and upgrades run-of-mine coal thereby creating a final coal product prior to shipping or consumption, and facilities (i.e., slurry pond, fresh water pond, conveyances) directly associated with the recycling or discharge of waters used during the "preparation" of coal.

preparation plant ancillary or associated areas: Areas that are interrelated with coal preparation or coal load out activities but do not include the preparation plant building and the preparation plant water recycle/discharge system. Said areas include but are not limited to ancillary buildings associated with coal preparation; disturbed areas in proximity to the preparation plant or related preparation activities; coal stockpiles; coal refuse storage areas; coal haulroads and refuse haulroads in proximity to the preparation plant or coal refuse storage site; treatment systems designed to handle runoff or seepage from preparation plant "disturbed" areas, or coal refuse piles etc.

priority pollutants: Those pollutants included in Table 1 of Committee Print Numbered 95-30 of the "Committee on Public Works and Transportation of the House of Representatives," subject to the Clean Water Act of 1977, and included in Table VI-1 of this document.

pyrites: Mineral group composed of iron and sulfur found in coal as FeS_2.

rank of coal: A classification of coal based upon the fixed carbon on a dry weight basis and the heat value.

raw mine drainage: Untreated or unprocessed water drained, pumped or siphoned from a mine.

reagent: A chemical or solution used to produce a desired chemical reaction; a substance used in flotation.

reclamation: The procedures by which a disturbed area can be reworked to make it productive, useful, or aesthetically pleasing, consisting primarily of regrading and revegetation.

reduction: A chemical reaction which involves the addition of electrons to a species.

refuse pile: Waste material from a preparation plant. The material includes pyrites, ash, and water or chemicals used in cleaning the coal.

regression model: A mathematical model, usually a single equation, developed through the use of a least squares linear regression analysis.

reserve: That part of an identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination.

residuals: The differences between the expected and actual values in a regression analysis.

reverse osmosis: The process of diffusion of a solvent through a semipermeable membrane from a solution of higher to one of lower solute concentration, effected by raising the pressure of the more concentrated solution to above the osmotic pressure.

riprap: Rough stone of various sizes placed compactly or irregularly to prevent erosion.

room and pillar mining: A system of mining in which the distinguishing feature is the mining of 50 percent or more of the coal in the first working. The coal is mined in rooms separated by narrow ribs (pillars); the coal in the pillars can be extracted by subsequent working in which the roof is caved in successive blocks.

runoff: That part of precipitation that flows over the land surface from the area upon which it falls.

sampler: A device used with or without flow measurement to obtain any adequate portion of water or waste for analytical purposes. May be designed for taking a single sample (grab),composite sample, continuous sample, or periodic sample.

sampling stations: Locations where several flow samples are tapped for analysis.

scarification: The process of breaking up the topsoil prior to mining.

sediment: Solid material settled from suspension in a liquid medium.

sedimentation: The gravity separation of settleable, suspended solids in a settling basin or lagoon.

settleable solids: (1) That matter in wastewater which will not stay in suspension during a preselected settling period, such as 1 hour but either settles to the bottom or floats to the top. (2) In the Imhoff cone test, the volume of matter that settles to the bottom of a 1-liter cone in 1 hour.

Settlement Agreement of June 7, 1976: Agreement between the U.S. Environmental Protection Agency (EPA) and various environmental groups, as instituted by the United States District Court for the District of Columbia, directing the EPA to study and promulgate regulations for a list of chemical substances, referred to as Appendix A Pollutants.

settling pond: A pond, natural or artificial, for recovering solids from an effluent.

significance: A statistical measure of the validity, confidence, and reliability of a figure.

sludge: Accumulated solids separated from a liquid during processing.

sluice: To cause water to flow at high velocities for wastage, for purposes of excavation, ejecting debris, etc.

slurry: Solid material conveyed in a liquid medium.

spoil material: Overburden that is removed from above the coal seam; usually deposited in previously mined areas.

statistical variance: The sum of the squared deviations about the mean value in proportion to the likelihood of occurrence. A measure used to identify the dispersion of a set of data.

subsidence: Surface depression created by caving of the roof material in an underground mine.

sump: Any excavation in a mine for the collection of water for pumping.

suspended solids: (1) Solids which either float on the surface of or are in suspension in water, wastewater, or other liquids, and which are removable by a .45 micron filter. (2) The quantity of material removed from wastewater in a laboratory test, as prescribed in "Standard Methods for the Examination of Water and Wastewater" and referred to as nonfilterable residue, measured in mass per unit volume (e.g., mg/l).

surface active agent: One which modified physical, electrical, or chemical characteristics of the surface of solids and also surface tensions of solids or liquid. Used in froth flotation (see also depressing agent, flotation agent).

syncline: A fold that is concave upward. The younger strata are closest to the axial plane of the fold.

table, air: a vibrating, porous table using air currents to effect gravity concentration of sands or other waste material from coal.

terracing: The act of creating horizontal or near horizontal benches.

thickener: A vessel or apparatus for reducing the amount of water (or conversely, increasing the concentration of settled material)in a wastewater stream.

tolerance limits: Numerical values identifying the acceptable range of some variable.

turbidity: Is a measure of the amount of light passing through a volume of water, which is directly related to the suspended solids content.

weir: An obstruction placed across a stream for the purpose of diverting the water so as to make it flow through a desired channel, which may be an opening or notch in the weir itself.

yellowboy: Salt of iron and sulfate formed by treating acid mine drainage (AMD) with lime; $FeSO_4$.

ABBREVIATIONS

Ag	Silver
Al	Aluminum
As	Arsenic
BADT	Best Available Demonstrated Technology
BATEA (BAT)	Best Available Technology Economically Achievable
BCPCT (BCT)	Best Conventional Pollutant Control Technology
Be	Beryllium
BFR	Big Flushing Rain
BMP	Best Management Practices
BOD	Biochemical Oxidation Demand
BPCTCA (BPT)	Best Practicable Control Technology Currently Available
Ca	Calcium
Cd	Cadmium
CN	Cyanide
COD	Chemical Oxygen Demand
CPE	Catastrophic Precipitation Event
Cr	Chromium
Cu	Copper
CWA	Clean Water Act of 1977
DM	Dissolved Metals
EPA	Environmental Protection Agency
Fe	Iron
FWPCA	Federal Water Pollution Control Act of 1972
Hg	Mercury
Mg	Magnesium
Mn	Manganese
Na	Sodium
Ni	Nickel
NPDES	National Pollution Discharge Elimination System
NSPS	New Source Performance Standards
OSM	Office of Surface Mining (Reclamation and Enforcement)
Pb	Lead
pH	$-\log_{10} [H^+]$
POTW	Publicly Owned Treatment Works

ABBREVIATIONS (Continued)

PSES	Pretreatment Standards for Existing Sources
PSNS	Pretreatment Standards for New Sources
RCRA	Resource Conservation and Recovery Act of 1976
Sb	Antimony
Se	Selenium
SMCRA	Surface Mining Control and Reclamation Act of 1977
SS	Settleable Solids
TDS	Total Dissolved Solids
Tl	Thallium
TM	Total Metals
TS	Total Solids
TSS	Total Suspended Solids
Zn	Zinc

Units

FTU	Franklin Turbidity Unit
JTU	Jackson Turbidity Unit
kkg	thousand kilograms
mgd	million gallons per day
mg/l	milligram(s) per liter
mty	million tons per year
ppb	part(s) per billion
ppm	part(s) per million
t	ton
NTU	Nephelometric Turbidity Unit
ug/l	microgram(s) per liter

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